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Agency

Great Lakes National
Program Office
536 South Clark Street
Chicago, Illinois 60605

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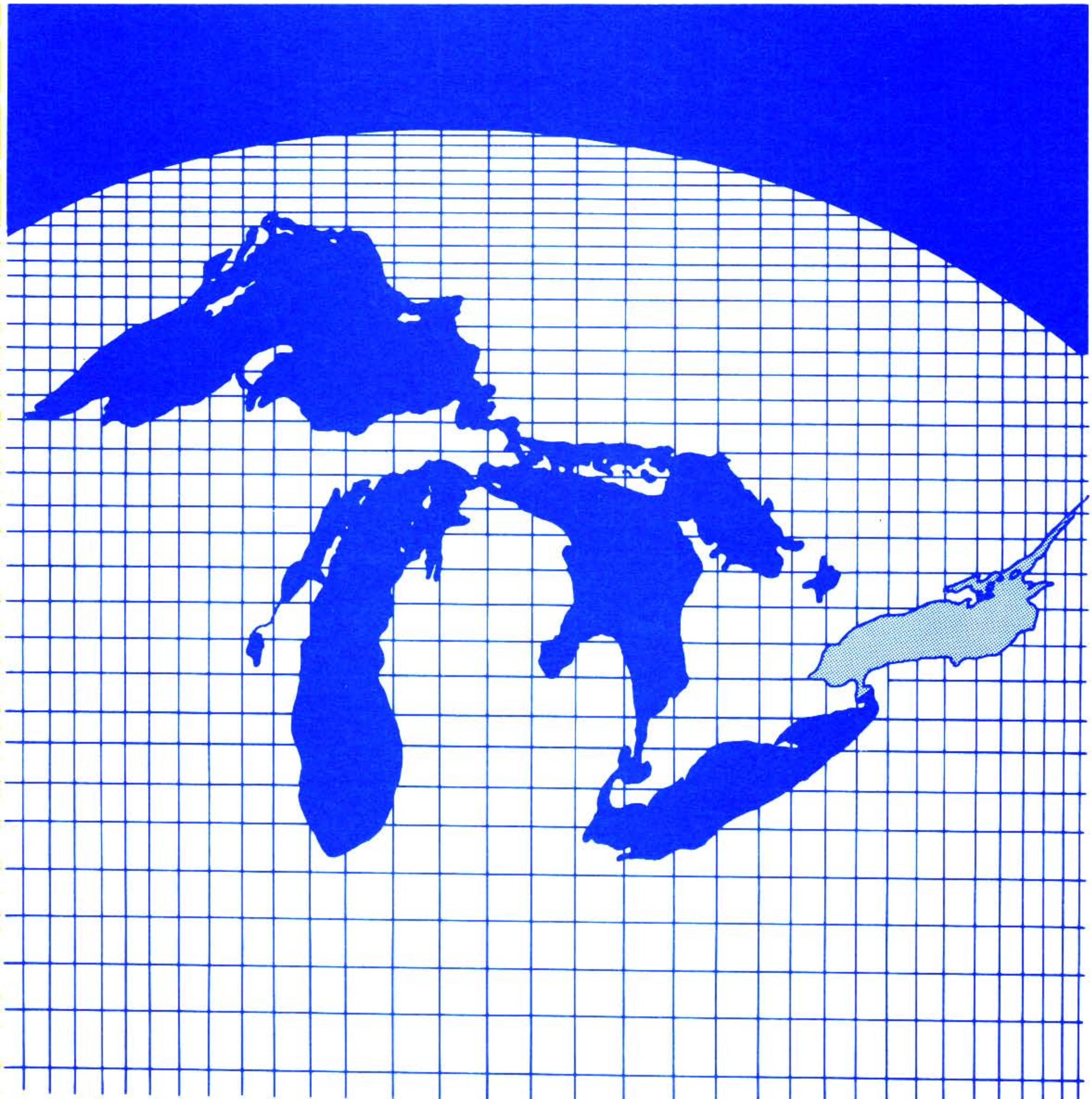
Limnology and Phytoplankton Structure In Nearshore Areas of Lake Ontario: 1981



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Limnology and Phytoplankton Structure in Nearshore Areas of Lake Ontario 1981

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with reports by

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Foreword

The Great Lakes National Program Office (GLNPO) of the United States Environmental Protection Agency was established in Region V, Chicago to focus attention on the significant and complex natural resource represented by the Great Lakes.

GLNPO implements a multi-media environmental management program drawing on a wide range of expertise represented by universities, private firms, State, Federal, and Canadian Governmental Agencies and the International Joint Commission. The goal of the GLNPO program is to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes system. The Office also coordinates U.S. actions in fulfillment of the Agreement between Canada and the United States of America on Great Lakes Water Quality of 1978.

CONTENTS

Lake Ontario 1981 Limnology Survey:

Niagara, Rochester, Oswego

Areas

by

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TABLE OF CONTENTS

Table of Contents (con't)

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

OBJECTIVES OF SURVEILLANCE PROGRAM

Monitoring and surveillance of the water quality of the Great Lakes and of connecting waterways are vital if we are to determine the most practical means for protecting these irreplaceable freshwater supplies from physical, chemical, and bacteriological health hazards. In 1975, the International Joint Commission Great Lakes Water Quality Board designed a long-term monitoring plan for the Great Lakes Basin that provided for a nine year cycle of intensive studies on each lake. Monitored during the intensive study of 1981-1982 were nearshore areas of Lake Ontario where impaired water quality had been previously reported.

The Great Lakes Water Quality Agreement requires the determination of specific objectives based on "statistically valid sampling data." This surveillance program was designed to provide statistically valid data for the support of federal, state and local remedial programs. These data can further be used to provide a statistical basis for the design of additional suveys for obtaining information about the prevention, reduction and eventual control of pollution in the nearshore areas of the Great Lakes.

The surveillance program for the Lake Ontario nearshore was designed with two objectives in mind:

1. To determine the status of the harbor and nearshore waters in 1981 to compare with the standards, criteria and objectives for the protection of raw water supplies and aquatic life in Lake Ontario.

2. To provide a data set which would characterize the water and sediment chemistry and phytoplankton of these environments.

AUTHORITY FOR STUDY

The Federal Water Pollution Control Act as amended in 1972 by Public Law 92-500, Section 108(a), authorized the USEPA to enter into agreements and to carry out projects to control and eliminate pollution in the Great Lakes Basin. Section 104(f) of the law provides the authority to conduct research, technical development, and studies with respect to the quality of the waters of the Great Lakes. Section 104(h) grants authority to develop and to demonstrate new or improved methods for the prevention, removal, reduction and elimination of pollution in the lakes. The Boundary Water Treaty between the United States of America and Canada in Annex 2, paragraph 10, of the Great Lakes Water Quality Agreement requires both countries to monitor the extent of eutrophication in the Great Lakes system and to develop measures to control phosphorus and other nutrients. Article V(f) requires consideration of measures for the abatement and control of pollution from dredging activities. The Agreement, signed in 1972, was reaffirmed in 1978.

METHODS AND MATERIALS

The methods that were employed are described in detail in Rockwell et al. (1980). A brief overview of these methods follows:

SURVEY PLAN

During 1981, the U.S. Environmental Protection Agency (USEPA) undertook four surveys of the Niagara River Plume, Rochester Embayment and Oswego Harbor, and nearshore waters during the periods April 22-May 5, July 21-August 5, August 18-September 2, and September 23-October 5. The water quality monitoring sites are displayed in Figures 1-4. The latitude and longitude coordinates for the sites are given in Table 1. The analytical schedule is presented in Table 2. Most stations were visited three times each survey (Table 3).

Sediment surveys were done during the third survey in the Genessee River, (Rochester, New York area), Plum Creek (Oswego, New York area), and at Eighteen Mile Creek in Olcott, New York (east of the Niagara River). The results of these surveys are reported in Kizlauskas et al. (1984).

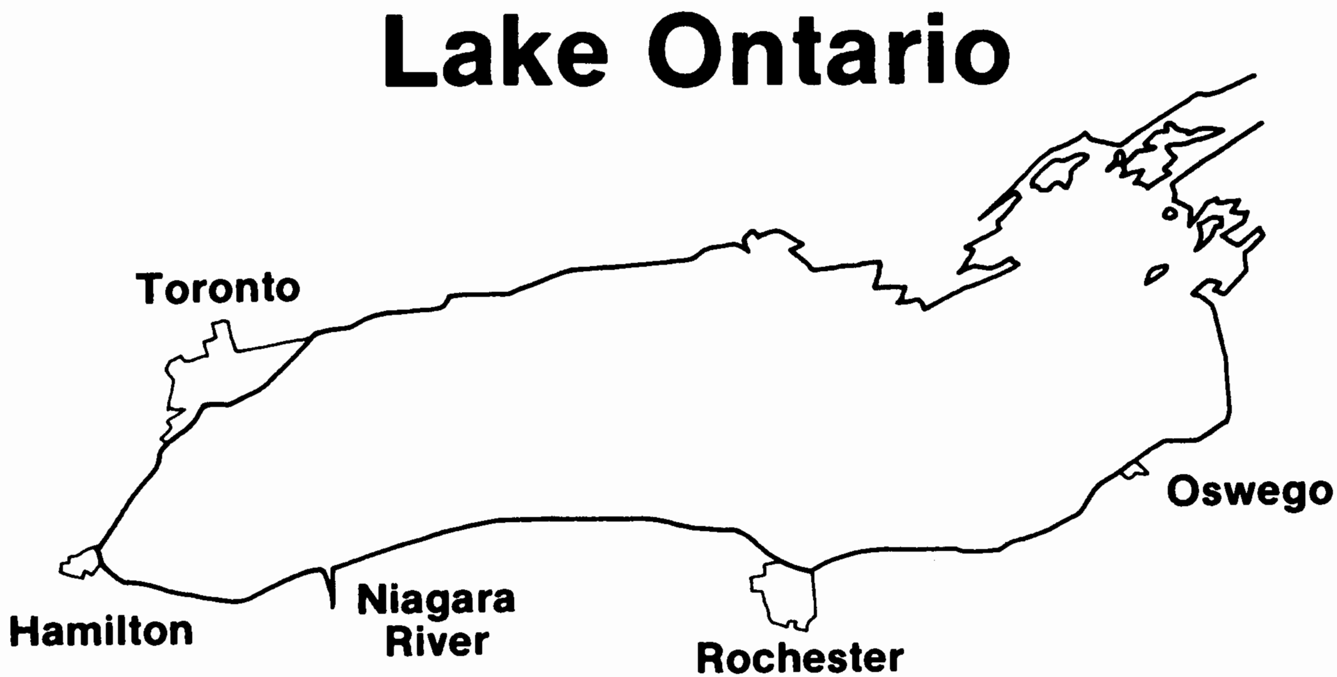

Figure 1. Lake Ontario with locations of the Niagara River mouth and the Cities of Rochester and Oswego.

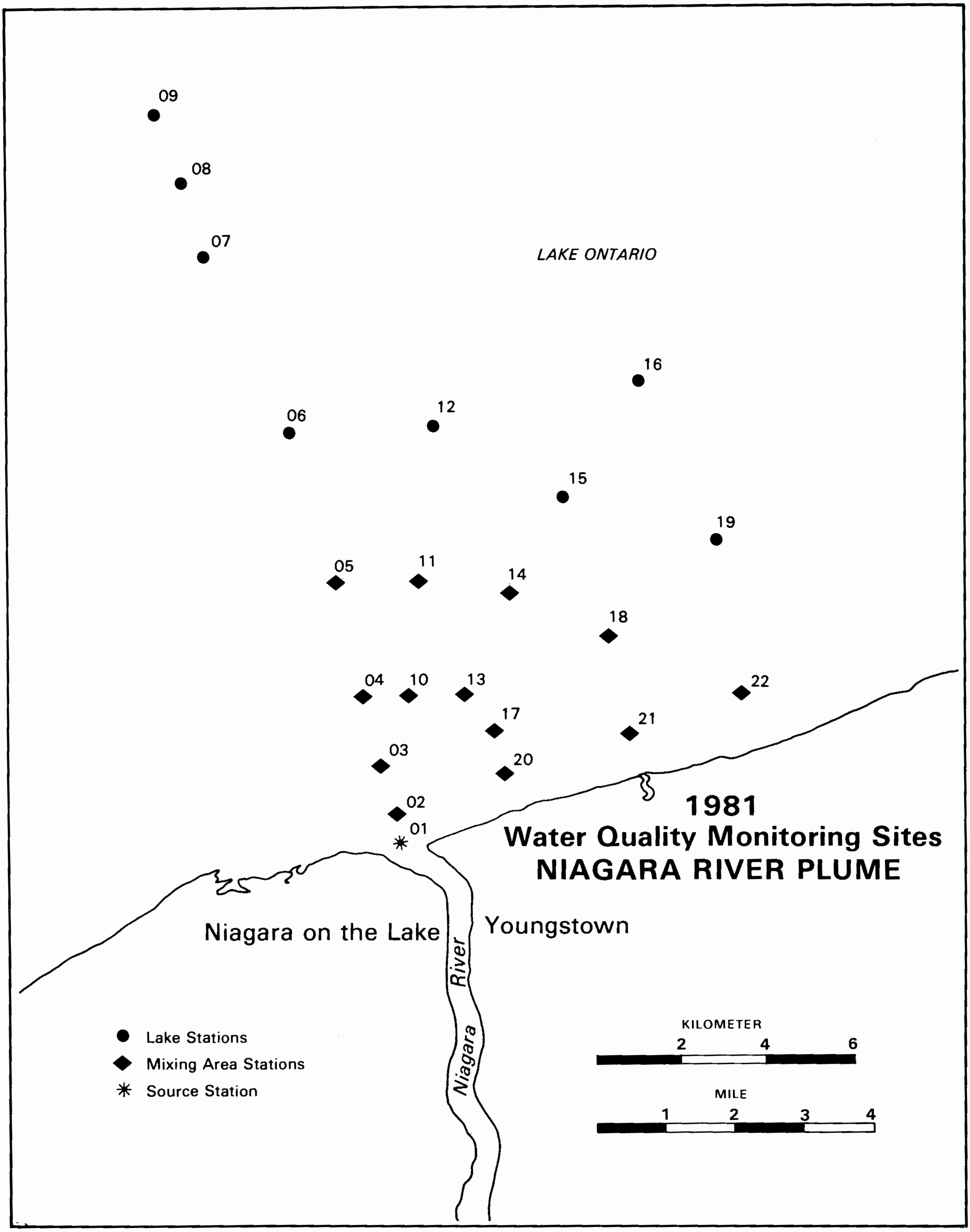

Figure 2. Water quality monitoring sites at the Niagara River Plume area.

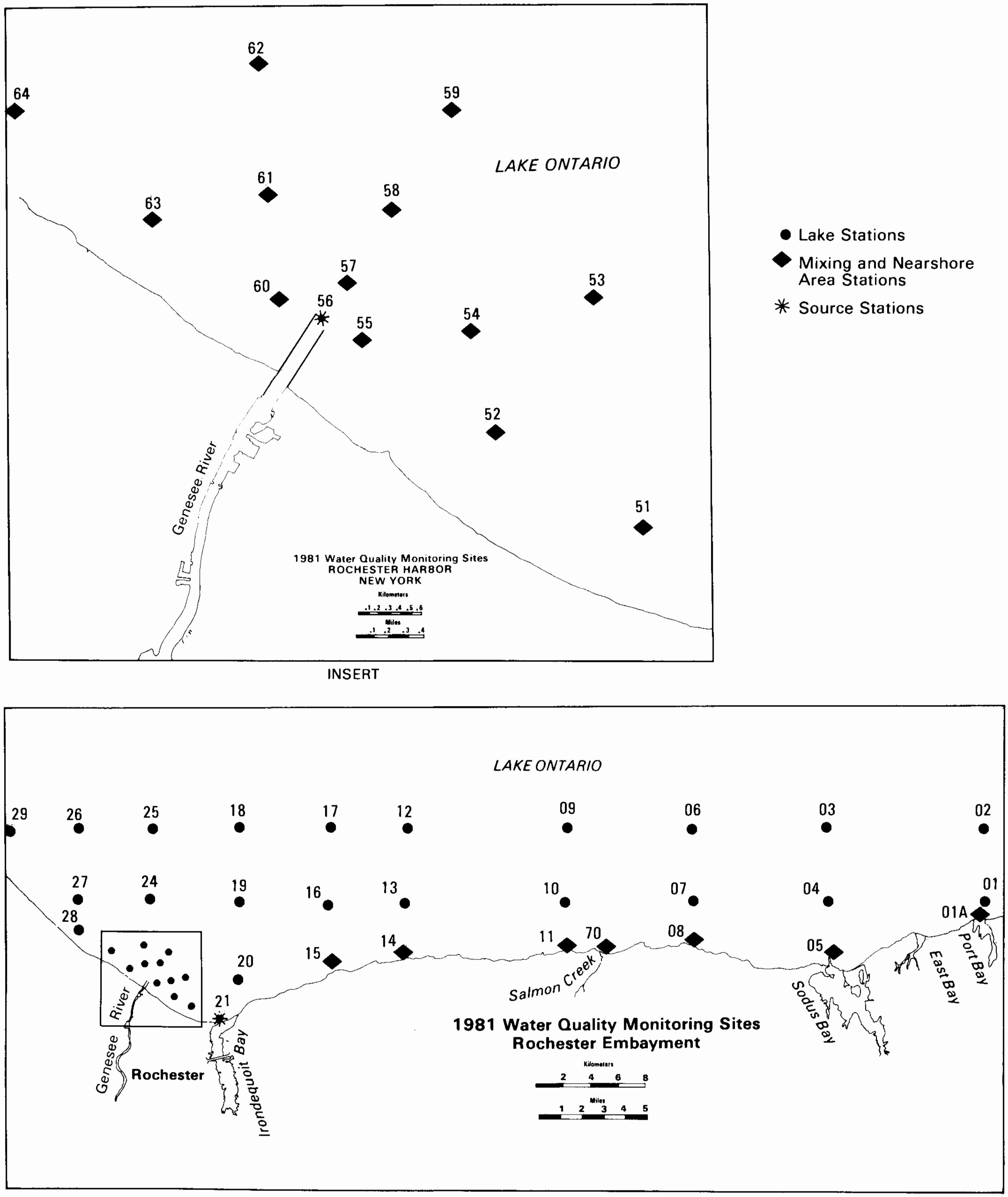

Figure 3. Water quality monitoring sites at the Rochester Embayment Area. The inset shows the location of stations near the Genesee River.

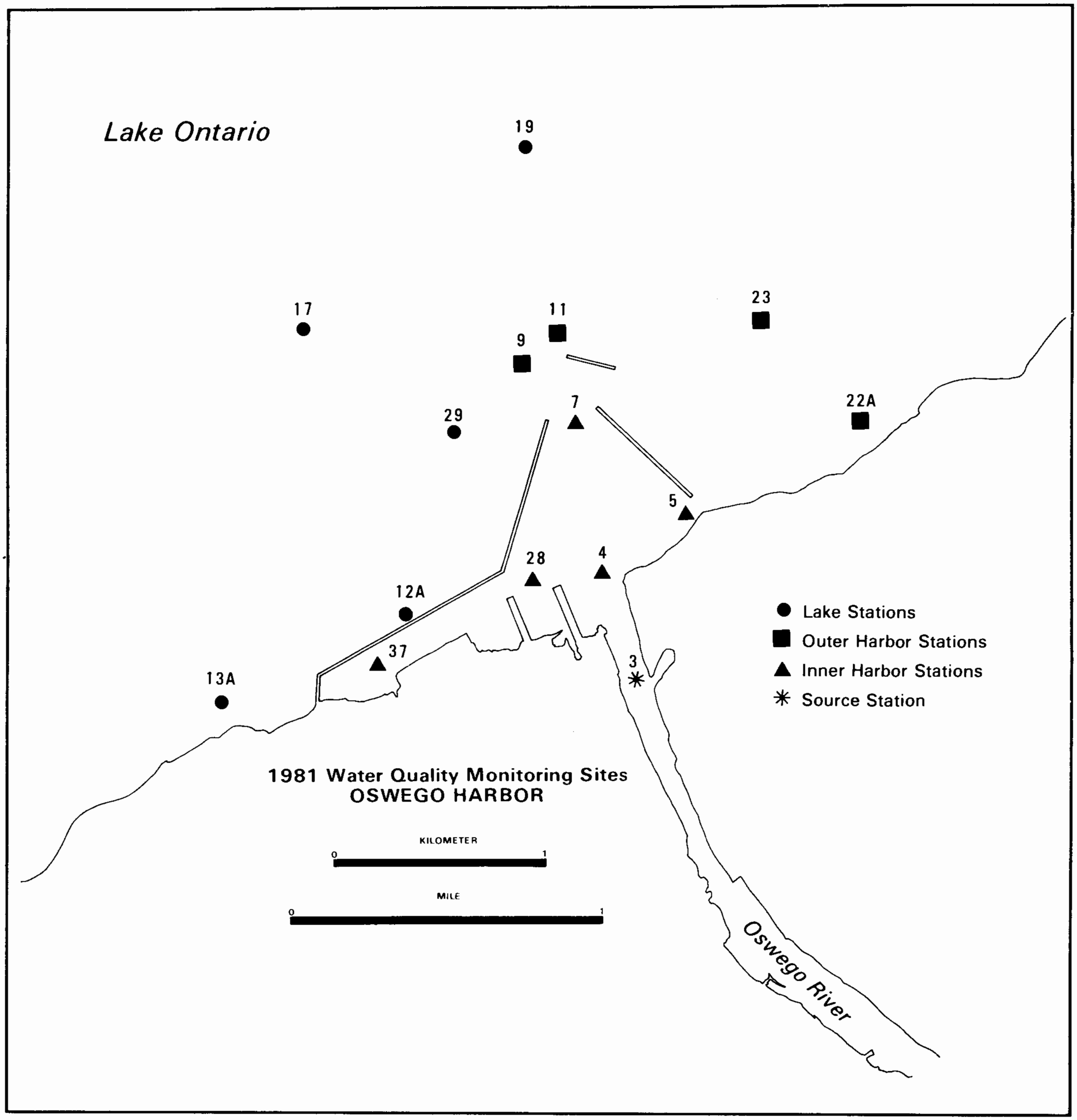

Figure 4. Water quality monitoring sites at the Oswego Harbor area.

Table 1 Station Locations: Niagara River Plume

Station No.	Latitude			Longitude			Approx. Depth (m)	Comments [a]
NIAG 01	43°	15'	45"	79°	04'	15"	15	M,PI,Spec.
NIAG 02	43	16	15	79	04	24	4.5	M,PI
NIAG 03	43	16	55	79	04	40	7.3	M,PI
NIAG 04	43	17	45	79	05	00	5.1	PI
NIAG 05	43	19	15	79	05	33	11	M,PI
NIAG 06	43	21	07	79	06	15	91	M,PD
NIAG 07	43	23	20	79	07	40	100	M,PI
NIAG 08	43	24	20	79	08	00	110	M,PI
NIAG 09	43	25	15	79	04	30	120	M,PI
NIAG 10	43	17	50	79	04	15	6.7	M,PI
NIAG 11	43	19	18	79	04	00	15	PI
NIAG 12	43	21	12	79	03	45	45	M,PI
NIAG 13	43	17	45	79	03	15	7.6	M,PI
NIAG 14	43	19	05	79	02	25	13	PI
NIAG 15	43	20	15	79	01	27	64	M,PD
NIAG 16	43	21	40	79	00	00	36	M,PI
NIAG 17	43	17	20	79	02	42	6.1	M,PI
NIAG 18	43	18	30	79	00	42	12	PI
NIAG 19	43	19	40	78	58	45	41	M,PI
NIAG 20	43	16	45	79	02	24	6.1	M,PI
NIAG 21	43	17	15	79	00	15	6.7	PI
NIAG 22	43	17	45	78	58	18	11	M,PI

[a] See below for explanation of comment codes

Table 1 con't Station Locations: Rochester Embayment

Station No.	Latitude			Longitude			Approx. Depth	Comments [a]
ROCH 01	43°	19'	00"	76°	50'	00"	5.5	M,PI
ROCH 02	43	22	00	76	50	00	42	M,PI
ROCH 03	43	22	00	76	59	00	85	M,PI
ROCH 04	43	19	00	76	59	00	36	M,PI
ROCH 05	43	16	45	76	59	00	4.5	M,PI,spec.
ROCH 06	43	22	00	77	06	00	106	PI
ROCH 07	43	19	00	77	06	00	39	PI
ROCH 08	43	17	30	77	06	00	5.5	PI
ROCH 09	43	22	00	77	13	00	121	M,PI
ROCH 10	43	19	00	77	13	00	41	M,PI
ROCH 11	43	17	16	77	13	00	6.7	M,PI
ROCH 12	43	22	00	77	22	00	151	M,PI
ROCH 13	43	19	00	77	22	00	45	M,PI
ROCH 14	43	16	54	77	22	00	7.3	M,PI
ROCH 15	43	16	35	77	26	00	5.5	PD
ROCH 16	43	19	00	77	26	00	61	PI
ROCH 17	43	22	00	77	26	00	167	PI
ROCH 18	43	22	00	77	31	00	110	M,PI
ROCH 19	43	19	00	77	31	00	49	M,PI
ROCH 20	43	16	00	77	31	00	23	M,PI
ROCH 21	43	14	40	77	31	00	3.6	M,PI
ROCH 24	43	19	00	77	36	00	27	M,PI
ROCH 25	43	22	00	77	36	00	73	M,PI
ROCH 26	43	22	00	77	40	00	60	M,PI
ROCH 27	43	19	00	77	40	00	10	M,PI
ROCH 28	43	17	47	77	40	00	4.5	M,PI
ROCH 29	43	22	00	77	40	00	30	M,PI
ROCH 51	43	14	42	77	33	40	5.5	M,PI
ROCH 52	43	15	10	77	34	41	5.5	PI
ROCH 53	43	15	54	77	34	00	15	M,PI
ROCH 54	43	15	44	77	34	51	8.5	PI
ROCH 55	43	15	42	77	35	38	5.0	M,PI
ROCH 56	43	15	48	77	35	56	7.3	M,PI,spec
ROCH 57	43	16	00	77	35	45	7.3	M,PI
ROCH 58	43	16	22	77	35	26	12	PI
ROCH 59	43	16	53	77	35	00	18	M,PI
ROCH 60	43	15	54	77	36	14	4.5	M,PI
ROCH 61	43	16	27	77	36	18	9.4	PI
ROCH 62	43	17	12	77	36	25	15	M,PI
ROCH 63	43	16	20	77	37	07	3.6	PI
ROCH 64	43	16	55	77	38	07	6.7	M,PI
ROCH 70	43	17	15	77	10	54	4.5	M,PI,spec.

[a] See below for explanation of comment codes

Table 1 con't Station Locations: Oswego Harbor

Station No.	Latitude	Longitude	Approx. Depth(m)	Comments [a]
OSW 03	43° 27' 40"	76° 30' 42"	6.4	M,PI,spec,
OSW 04	43 28 03	76 30 50	7.6	M,PI
OSW 05	43 28 08	76 30 31	2.7	M,PI
OSW 07	43 28 24	76 30 56	8.2	M,PI
OSW 09	43 28 34	76 31 08	8.2	M,PI
OSW 11	43 28 39	76 31 00	7.6	M,PI
OSW 12A	43 27 52	76 31 35	6.4	M,PI
OSW 13A	43 27 37	76 32 17	4.5	M,PI
OSW 17	43 28 40	76 31 58	15	M,PD
OSW 19	43 29 10	76 31 07	14	M,PD
OSW 22A	43 28 24	76 29 51	1.5	M,PI,spec
OSW 23	43 28 41	76 30 13	6.7	M,PI
OSW 28	43 27 57	76 31 06	7.6	M,PI
OSW 29	43 28 22	76 31 24	9.7	M,PI
OSW 37	43 27 43	76 31 42	7.6	M,PI,spec.

[a] See below for explanation of comment codes

M - Metals, see Table 2 for parameters
PI - Integrated phytoplankton
PD - Discrete phytoplankton
Spec - Phenol, organic

Samples for chlorophyll were taken from the same Niskins as the phytoplankton sample. These followed the phytoplankton sampling pattern of integrated and discrete samples.

Integrated phytoplankton samples were obtained by combining equal amounts of 1,5,10,15, and 20 meter samples. When the water depth was less than 20 meters, the B-2 sample replaced the lowest obtainable depth.

Discrete phytoplankton samples were collected at 1,5,10,15,20,25,30,40,75,100, 150,B-2 meter depths.

Table 2 Analytical Collection Schedule

Measurements	Stations	Runs	Depths	Survey	Remarks
Water Temperature	All	All	All	All	Vertical profile required if depth was 10 meters or greater.
Wind Speed & Direction	All	All	---	All	
Secchi	All	All	---	All	
Wave height	All	All	---	All	
Aesthetics	All	All	---	All	
Turbidity	All	All	All	All	
Dissolved Oxygen	All	All	All	All	Profile required if thermocline existed
pH	All	All	All	All	
Specific Conductivity	All	All	All	All	
Alkalinity	All	All	All	All	
Total Phosphorus	All	All	All	All	
Total Dissolved Phosphorus	All	All	All	All	
Soluble Reactive Phosphorus	All	All	All	All	
Total Kjeldahl Nitrogen	All	First	All	All	
Ammonia nitrogen	All	All	All	All	
NO_2 + NO_3 Nitrogen	All	All	All	All	
Dissolved Reactive Silica as Silicon	All	All	All	All	
Chloride	All	All	All	All	
Sulfate	All	First	All	All	
Calcium	All	First	1 m.	All	
Magnesium	All	First	1 m.	All	
Sodium	All	First	1 m.	All	
Total Iron	M	First	1 m.	Third	
Total Lead	M	First	1 m.	Third	
Total Mercury	M	First	1 m.	Third	
Total Copper	M	First	1 m.	Third	
Total Zinc	M	First	1 m.	Third	
Total Nickel	M	First	1 m.	Third	

Table 2 con't — Analytical Schedule

Measurements	Stations	Runs	Depths	Cruise	Remarks
Total Cadmium	M	All	1 m.	Third	
Total Chromium	M	First	1 m.	Third	
Phenol	Spec.	All	All	All	
Phytoplankton	PI,PD	First	20 m.		Integrated or discrete
Chlorophyl-a	PI,PD	All	20 m.		Integrated
Pheophytin	PI,PD	All	20 m.		Integrated

M - See Table 1 for sites
PI - Integrated phytoplankton
PD - Discrete phytoplankton
Spec - See Table 1 for sites

Table 3 1981 Niagara River Plume Field Program Sampling Dates

	First Survey				Second Survey					Third Survey			Fourth Survey		
Stations	4/22	4/23	4/24	4/25	8/02	8/03	8/04	8/05	8/30	8/31	9/1	9/2	10/8	10/9	10/10
NIAG 01	X	X	X			X	X	X	X	X	X	X	X	X	X
02	X	X	X			X	X	X		X	X	X	X	X	X
03	X	X	X			X	X	X		X	X	X	X	X	X
04	X	X	X			X	X	X		X	X	X	X	X	X
05			X	X		X	X	X		X	X	X	X	X	X
06	X		X	X	X				X				X		
07	X		X	X	X				X				X		
08	X		X	X											
09	X		X	X	X				X				X		
10	X	X	X			X	X	X		X	X	X	X	X	X
11			X	X		X	X	X		X	X	X	X	X	X
12			X	X	X				X				X		
13	X	X	X			X	X	X		X	X	X	X	X	X
14	X	X	X			X	X	X		X	X	X	X	X	X
15	X	X	X		X	X	X	X		X	X	X	X	X	X
16	X	X	X		X				X				X		
17	X	X	X			X	X	X		X	X	X	X	X	X
18	X	X	X			X	X	X		X	X	X	X	X	X
19	X	X	X		X	X	X	X		X	X	X	X	X	X
20	X	X	X			X	X	X		X	X	X	X	X	X
21	X	X	X			X	X	X		X	X	X	X	X	X
22	X	X	X			X	X	X		X	X	X	X	X	X

Table 3 con't

1981 Rochester Embayment Field Program Sampling Dates

Station	First Survey						Second Survey										Third Survey									Fouth Survey								
	4/29	30	5/1	2	3	4	7/21	22	23	24	25	26	27	28	29	30	8/18	19	20	21	22	23	24	25	26	9/23	24	25	26	27	28	29	30	10/1
ROCH 01	X															X				X										X		X		X
01A									X	X																								
02	X								X	X						X			X	X					X					X		X		X
03	X								X	X						X			X	X					X					X		X		X
04	X								X	X					X				X	X					X									
05	X								X	X						X			X	X					X					X		X		X
06	X								X	X					X				X	X					X					X		X		X
07	X								X	X					X				X	X					X					X		X		X
08	X								X	X					X				X	X					X					X		X		X
09			X						X	X					X				X	X					X					X		X		X
10			X						X	X					X					X					X					X		X		X
11			X						X	X					X					X					X					X		X		X
12			X					X	X			X		X							X			X					X	X		X		
13			X					X	X			X		X				X			X			X					X	X		X		
14			X					X	X			X		X				X			X			X					X	X				
15			X					X				X		X				X			X			X			X		X					X
16			X					X				X		X				X			X			X			X		X					X
17			X					X				X		X				X			X			X				X	X					
18				X				X				X		X				X			X			X				X	X					
19				X				X				X		X				X			X			X			X		X					X
20				X				X				X		X							X			X			X		X					X
21				X				X				X		X						X	X							X	X				X	
24				X			X				X					X						X	X				X	X					X	
25				X			X				X		X				X					X	X					X					X	
26							X				X		X				X					X	X					X					X	
27		X					X				X		X				X					X	X			X		X					X	
28		X					X				X		X				X					X	X				X	X					X	
29						X	X				X		X				X					X	X					X					X	
51			X	X				X				X		X				X			X			X			X		X				X	
52			X	X				X				X		X				X			X			X			X		X				X	
53			X	X				X				X		X				X			X			X			X		X				X	
54			X	X				X				X		X				X			X			X			X		X				X	
55		X						X				X		X				X			X			X			X		X				X	
56		X					X				X		X					X				X	X				X	X					X	
57		X					X				X		X				X					X	X					X					X	
58		X					X				X		X				X					X	X					X					X	
59		X					X				X		X				X					X	X					X					X	
60		X					X				X		X				X					X	X					X					X	
61						X	X				X		X				X					X	X					X					X	
62			X		X		X				X		X				X					X	X					X					X	
63		X		X			X				X		X				X					X	X					X					X	
64		X					X				X		X				X					X	X					X					X	
70			X						X	X					X				X	X					X				X	X		X		X

Table 3 con't 1981 Oswego Harbor Area Field Program Sampling Dates

	First Survey		Second Survey			Third Survey			Fourth Survey			
Station	4/27	4/28	7/30	7/31	8/01	8/27	8/28	8/29	10/02	10/03	10/04	10/05
OSW 03	X	X	X	X	X	X	X	X	X	W	X	X
04	X	X	X	X	X	X	X	X	X	E	X	X
05	X	X	X	X	X	X	X	X	X	A	X	X
07	X	X	X	X	X	X	X	X	X	T	X	X
09	X	X	X	X	X	X	X	X	X	H	X	X
11	X	X	X	X	X	X	X	X	X	E	X	X
12A	X	X	X	X	X	X	X	X	X	R		X
13A	X	X	X	X	X	X	X	X				X
17	X	X	X	X	X	X	X	X	X		X	X
19	X	X	X	X	X	X	X	X	X	D	X	X
22A	X	X	X	X	X	X	X	X	X	A	X	X
23	X	X	X	X	X	X	X	X	X	Y	X	X
28	X	X	X	X	X	X	X	X	X		X	X
29	X	X	X	X	X	X	X	X	X		X	X
37	X	X	X	X	X	X	X	X	X		X	X

VESSEL

In the nearshore surveys the R/V Roger Simons was used. The R/V Simons was built in Duluth, Minnesota by the Marine Iron and Ship-Building Company in 1939 as a lighthouse tender. The vessel is of the WAGL type, 122' overall length; 27' beam; 7' maximum draft displacement; full load 342 tons; hull material, steel; twin screw, 460 SHP diesel propulsion.

STUDY AREAS AND STATION SELECTION

The locations of the stations in the nearshore area were selected from recommendations by the Lake Ontario Work Group for the Surveillance Subcommittee of the Great Lakes Water Quality Board (1979) under the directior of the International Joint Commission. The nearshore studies focused on the Niagara River Plume, the Rochester Embayment and the Oswego Harbor area. These studies included stations at the mouths of the Niagara River, Genessee River, and Oswego River. All stations in Lake Ontario were within 10 kilometers of the shore except in the Rochester Embayment where some stations were 15 kilometers from shore.

The sampling grids of stations included: 22 stations in the Niagara River Plume positioned in a grid of approximately one station per 2 square kilometers, 42 stations in the Rochester Embayment positioned in two grids of approximately one station per 0.75 square kilometer in the vicinity of the Genessee River, and of approximately 1 station per 7.5 square kilometers in the remainder of the Rochester Embayment; and 15 stations in the Oswego Harbor positioned in a grid of approximately one station per 0.25 square kilometer.

The sampling grids were arranged such that the river mouth stations radiated outward like the spokes of a wheel. This pattern was used in the Niagara River Plume and the Genessee River mixing area. Outside of the Genessee River mixing area, the Rochester Embayment station grid was basically rectangular with three transects roughly parallel to the shore. The distances from shore were approximately 1/2 km, 2 km, and 5 km respectively for each transect. Distance between stations along a transect varied from 3 km to 6 km. Station patterns in the Oswego Harbor were constrained by the breakwater walls, but were similar to the network used by GLERL in 1972 (Bell 1978). A string of stations was placed in the river, inner harbor, and outer harbor approximatey perpendicular to shore. Other stations were located roughly along two semi-circles about 1 km and 2 km from the center of the inner harbor to accomodate the complex harbor geometry and breakwater walls.

DEPTH SELECTION

Chemistry

Each station was sampled when possible, at 1,5,10, and 20 meters below the surface and at 2 meters above the bottom (B-2). Additional samples were taken from thermally stratified stations at mid thermocline, 1 meter above the upper knee and 1 meter below the lower knee of the metalimnion. Any of the fixed depths that were within 3 meters of the thermocline depths were deleted.

Biology

Phytoplankton samples were obtained by integrating equal amounts of water from 1,5,10,15, and 20 meters below the surface. If the water column was less than 20 meters, the B-2 sample replaced an appropriate depth. Discrete phytoplankton samples at 1,5,10,15,20,25,30,40,75,100,150,B-2 meters below the surface were obtained at selected locations (see Table 1). Samples for chlorophyll-a were taken from the same Niskin as the phytoplankton sample.

SAMPLING PROCEDURES

The analytical schedule for the parameters measured during the lake surveys in 1981 is displayed in Table 2. A 12 bottle Rosette sampler system (General Oceanics Model 1015-12-8) was used to collect water samples. This system consisted of an electrobathythermograph (EBT) Guideline Model 8705 attached to an eleven bottle array, an A-frame, 300 meters of multi-conductor cable, and a 5HP variable speed winch.

Temperature and depth were recorded on an xy plotter (Hewlett Packard model 7046A) as the Rosette was lowered to the bottom. Water samples were collected by closing the Niskin bottles as the Rosette was raised to the surface. After the samples were brought on board, they were distributed to the sample storage bottles while the Niskin bottles remained in the Rosette.

Water samples were processed as illustrated in Figure 5. Each Niskin sampling bottle was emptied into the sample storage bottles normally within one minute, and never more than 10 minutes, after collection. All chemistry sample bottles were rinsed once with sample before filling. New polyethylene containers (PEC), one gallon or two and one half gallons, were used to hold the samples for the on-board analyses and preparations. A duplicate temperature measurement was made on the sample in the surface Niskin bottle or the phytoplankton sample storage bottle to check the EBT thermistor reading.

Dissolved nutrient samples were prepared by vacuum filtration of an aliquot from the PEC for onboard analyses within an hour of sample collection. Most samples were filtered within 30 minutes of collection. A 47 mm diameter, 0.45 um pore size cellulose acetate membrane filter held in a polycarbonate

Raw Water From 8-Liter Niskin Bottle

—> 960 ml polyethylene bottle (water temperature)
—> 300 ml BOD bottle (dissolved oxygen) [Winkler at bottom]
—> 125 ml polyethylene with 1 ml/L conc. H_2SO_4 (for TKN and Total P)
—> 125 ml polyethylene with 5 ml/L 8N nitric acid (for Na,Ca,Mg)

One gallon polyethylene cubitainer

—> 100 ml (pH)
—> 100 ml (total alkinity, titration)
—> 500 ml (specific conductivity)
—> 100 ml (turbidity) [onboard and in situ - via transmissometer]
—> 20 ml (ammonia nitrogen, chloride and sulfate)

—> Filter Sartorius 0.45um membrane
Filtrate 100 ml (dissolved nutrients - nitrate+nitrite-nitrogen, dissolved reactive silica, and soluble reactive phosphorus, total dissolved phosphorus)

—> Filter 100 ml Gelman type AE (glass fiber)
Filters - chlorophyll-a and pheophytin

Composite sample or integrated sample (surface to 20 meter depth or B-2, whichever is smaller)

—> Filter 100 ml Gelman type AE (glass fiber) previously fired at 500°C
Filter - acidify, desiccate, freeze for Particulate Organic Carbon
—> Filter 100 ml Gelman type AE (glass fiber)

Filters - Chlorophyll-a and pheophytin

Raw Water
—> 960 ml polyethylene bottle with 10 ml Lugol's solution for phytoplankton sample
—> 125 ml polyethylene bottle with 1 ml/L con. H_2SO_4 (TKN)
—> 125 ml polyethylene (total P)

Sub-surface sample (one liter) for trace metals collected with an all-plastic sampler as vessel came on station.

Figure 5 Flow Chart Illustrating Sample Processing on USEPA's R/V Roger Simons Research Vessel filter holder (Millipore XX 11 04710) with a polypropylene filter flask was prewashed with 100 to 200 ml of demineralized water or sample water. New 125 ml polyethylene sample bottles with linerless closures were rinsed once with filtered sample prior to filling.

A 10 ml aliquot was removed for immediate analysis of dissolved orthophosphate and dissolved silica, after which the remainder was preserved with 1 ml/l concentrated sulfuric acid, and subsequently analyzed for total dissolved phosphorus.

Trace metals, alkaline earth metals (Mg,Ca), and alkali metals (Na,K) were collected at master stations (Table 1) and analyzed at the Central Regional Laboratory, EPA, Chicago.

ANALYTICAL METHODS

Aesthetics

Reports of any unusual visual conditions that existed at any station were made. Conditions such as floating algae, detritus, dead fish, oil, unusual water color, or other abnormal conditions were recorded in the field observations.

Water Temperature

The vertical profiles of water temperature from surface to bottom were determined at each station with a Resistance Temperature Detector (RTD) with a 1.4 second time constant and recorded by the EBT. The RTD was assembled in a thin walled stainless steel tube which isolated it from contact with the water.

Temperatures recorded by the EBT were verified by use of a mercury thermometer (ASTM No. 90C). The thermometer shaft was immersed in the full Niskin bottle from the surface or in a 960 ml plastic bottle filled with water from the surface Niskin bottle. Readings were estimated to the nearest 0.1°C within one minute of sampling.

Air Temperature

Air temperature was determined by use of a dial scale bimetallic helix thermometer such as a Weston Model 4200. The thermometer was allowed to stabilize in the shade in an open area of the deck prior to recording the temperature to the nearest 0.5°C.

Wind Speed and Direction

Wind speed and direction readings from a permanently mounted Danforth Marine type wind direction and speed indicator were recorded to the nearest 1° (to the right of true north) with the vessel stopped. Wind direction was estimated to be accurate to $\pm 10°$. The reading of wind speed was estimated to the nearest nautical mile per hour.

Wave Height

Average wave height (valley to crest vertical distance) was estimated to the nearest 0.5 feet at each station by the senior crew member on the bridge and recorded to the nearest 0.1 meter. Wave direction was recorded as coinciding with wind direction.

Turbidity

Turbidity was measured with a Turner Nephelometer within 2 hours of sample collection. The turbidimeter was calibrated daily before analysis using a standard within the anticipated range of turbidity. Some turbidity samples were heated to 25°C to avoid condensation on the sample cuvet. Readings from 0 to 1 were recorded to the nearest 0.01 NTU. Readings in the 1 to 40 range were recorded to the nearest 0.1 NTU.

Secchi Disc Depth

Secchi disc depth was estimated to the nearest 0.5 meters at each station by use of a non-standard 30 cm, all-white, disc.

pH

Analyses for pH were made by electrometric measurement within 15 minutes of sample collection. Readings were recorded to the nearest 0.01 pH unit from an Orion model 701 pH meter equipped with an automatic temperature compensation probe. A combination glass membrane with a silver/silver chloride internal electrode element was used. The pH meters were standardized against two buffers, pH 7.0 and 9.0 (each prepared from Fisher Scientific concentrates), chosen to bracket the pH of Great Lakes water.

Chloride

A Technicon AutoAnalyzer System II was used with Technicon's Industrial Method No. 99-70W adjusted to a working range of 0 to 30 mg Cl/l. In this method, chloride ion displaces mercury from mercuric thiocyanate forming un-ionized soluble mercuric chloride. The released thiocyanate reacts with ferric ion to form intensely colored ferric thiocyanate which is determined photometrically. Raw water samples were stored non-refrigerated in 125 ml or 250 ml polyethylene bottles with plastic closures. Seven standards with 5 mg/l spread between adjacent concentrations were included with each group of samples. A regression technique was used to define the three constants ot a quadratic equation used for reduction of chart readings to concentrations (Alder and Roessler 1962).

Sulfate

Samples were analyzed for sulfate with a Technicon AutoAnalyzer using Technicon's Industrial Method 118-71W with 1 ml/min sample and diluent pump tubes to give a 0-30 mg/l range. In this procedure the sample was first passed through a cation-exchange column to remove interfering cations. It was then mixed with an equimolar solution of $BaCl_2$ and methyl thymol blue (MTB). Sulfate reacts with Ba reducing the amount of Ba available to react with MTB. The free MTB was then measured photometrically. Raw water samples, stored un-refrigerated in 125 ml or 250 ml polyethylene bottles with plastic closures were analyzed within 90 days of sample collection. Seven standards with 5 mg/l spread between adjacent concentrations were run with each group of samples. A regression technique was used to define the four constants of a cubic equation used for reduction of chart readings to concentration (Alder and Rossler 1962).

Specific Conductance

Specific conductance was determined within 2 hours of sample collection using a Barnstead model PM70CB conductivity bridge and a conductivity cell (YSI 3401 or YSI 3403). An immersion heater connected to a proportional electronic temperature controller with thermister sensor was used to heat the sample in a 250 ml polypropylene beaker to 25.0°C. The temperature was monitored with a mercury thermometer (ASTM 90C) with 0.1°C divisions. Rapid stirring was accomplished with an immersion glass paddle attached to a small electric motor. When the specific conductivity of a sample differed by more than 10% + 1 umhos/cm from the previous sample, a fresh aliquot was taken for the determination to minimize carry over from sample to sample. The apparatus was standardized daily against a solution of 0.15 gram KCL/l (Lind et al. 1959).

Total Alkalinity as ($CaCO_3$)

Total alkalinity was determined within 2 hours of sample collection by titration of a 100 ml aliquot to pH 4.5 with 0.02 N H_2SO_4. The pH controller/meter (Cole Parmer model 5997 with combination electrode) was standardized daily with pH buffers 4.0 and 7.0 (each prepared from Fisher Scientific concentrates). The acid was standardized against a solution of 0.2012 gram Na_2CO_3/l.

Total Calcium, Magnesium, Sodium

Discrete samples for these metals were taken at all depths. All metals were determined by Inductively Coupled Argon Plasma Emission Spectroscopy (ICAP). The samples were preserved immediately upon collection with 5 ml/l concentrated nitric acid.

Trace Metals

Samples for total trace metals were collected with an all plastic sampler and immediately transferred to pre-cleaned and "predosed" 1-liter bottles. The "dose" was 10 ml of 1+1 (vol:vol) redistilled nitric acid and reagent water. The samples were analyzed by atomic absorption using a graphite furnace and an automatic sampler.

The pre-cleaning protocol followed recommendations in Patterson and Settle (1976). Modifications to this method involved use of unheated NHO_3 to clean polyethylene bottles (Petrie 1980).

The all plastic sampler consisted of a 1-liter plastic polyethylene bottle attached to the end of a 1 inch interior diameter PVC pipe. Coupled to the PVC pipe was a lid which attached to the plastic bottle. The lid had a large hole in it contiguous with the hollow pipe. Holes in the PVC pipe just above the coupling allowed water to enter the PVC pipe and flow into the bottle through the perforated lid.

Phenols

Phenolic substances were determined using an autoanalyzer implementation of the direct 4AAP method following manual distillation, EPA 600/4-79-020 Method 420.

Dissolved Oxygen

Dissolved oxygen was measured in water samples from the B-2 depth at each station by the azide modification of the Winkler test (EPA 1979) immediately after sample collection. The aliquot for dissolved oxygen was obtained by inserting to the bottom of a 300 ml glass BOD bottle an 8 to 10 inch length of Tygon tubing that was connected to the outlet plug of the Niskin bottle. Flow was regulated by the outlet plug so as to minimize turbulence and admixture of the sample and air. Two to three bottle volumes were allowed to flow through the bottle.

Soluble Reactive Phosphorus

Filtered samples were analyzed for soluble reactive phosphorus using a Technicon AutoAnalyzer System II and a stannous chloride reduced phosphomolybdenum complex measured photometrically at a wave length of 660 um (Technicon Industrial Method No. 155-71W). Analyses were performed within 2 hours of sample collection.

Total Phosphorus and Total Dissolved Phosphorus

The various forms of phosphorus were converted to orthophosphate by an adaptation of the acid persulfate digestion method (Gales *et al*. 1966). Samples were transferred to acid washed digestion tubes and covered within 24 hours after collection. The digestion reagent was adjusted to produce 2 gm/l ammonium persulfate and 3 mg/l sulfuric acid in the final digestion solution. Screw-cap tubes containing the sample and digestion solution were heated in a forced air oven for 1/2 hour at 150°C. After cooling, the resulting orthophosphate was determined by the Technicon AutoAnalyzer System II and Technicon's Industrial Method 155-71W (Murphy and Riley 1962).

Total Organic Carbon

Samples were preserved with 1 ml/l concentrated sulfuric acid and stored in 125 ml polyethylene screw cap bottles until analysis. Approximately 10 ml of acidified sample was purged with 60 to 70 cc/min of prepurified nitrogen through a capillary tube for 5 minutes to remove inorganic carbon. A 50 ul sample was then injected into a Beckman Total Organic Carbon Analyzer Model 915B (EPA 1979).

Filtered Nitrate and Nitrite Nitrogen

A Technicon AutoAnalyzer was used with Technicon's Industrial Method No. 158-71W on filtered samples (Armstrong et al. 1967, EPA 1979). In this procedure nitrate is reduced to nitrite in a copper cadmium column, which is then reacted with sulfanilamide and N-1-napthylethylenediamine dihydrochloride to form a reddish purple azo dye. Nitrate and nitrite analyses were performed within 2 hours of collection.

Total Ammonia Nitrogen

Total ammonia nitrogen analyses were performed with a Technicon AutoAnalyzer System II using a modification of Technicon's Industrial Method 154-71W/ Tentative. The ammonia determinations were performed onboard within 8 hours of sample collection. Samples were maintained at 4°C until analyzed.

Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen samples were preserved for no longer than 90 days by the addition of 0.4 ml of 310 ml H_2SO_4/l to each 125 ml. Preservative was added to samples within 30 minutes of sample collection. Analyses were made by an "ultramicro semiautomated" method (Jirka, et al. 1976) in which a 10 ml sample was digested with a solution of K_2SO_4 and HgO in a block digestor at 370°C. After cooling and dilution with water, the sample neutralization and ammonia determination (Berthelot Reaction) were accomplished on a Technicon AutoAnalyzer System II.

Dissolved Reactive Silica

A Technicon AutoAnalyzer System II was used with Technicon's Industrial Method No. 186-72W/Tentative to determine dissolved reactive silica. This method is based on the chemical reduction of silico-molybdate in acid solution to "molybdenum blue" by ascorbic acid. Oxalic acid was added to eliminate interference from phosphorus. Analyses were performed on the filtered sample within 2 hours of sampling. The results were reported as silicon.

Chlorophyll-a and Pheophytin

Water samples for chlorophyll analysis (100 ml to 500 ml) were taken at all stations from the surface sample and were filtered at <7 psi vacuum along with 1 to 2 ml of $MgCO_3$ suspension (10 gm/1) usually within 30 minutes of sample collection. In some instances filtration was delayed for as long as 2 hours. The filters (Gelman type AE) were retained in a capped glass tube containing 10 ml of 90% spectrograde acetone at - 10°C in the dark for up to 30 days prior to completion of the analysis. The tubes were placed in an ultrasonic bath for at least 20 minutes and then allowed to steep for at least 24 hours prior to fluorometric analysis using an Aminco dual monochromator spectrofluorometer (Strickland and Parsons 1972).

DATA ANALYSIS APPROACH

The Data Base

The water quality data base was entered into the storage and retrieval system (STORET) of the EPA and contains approximately 39000 observations from 3300 samples encompassing 47 water quality parameters at 80 locations. The agency code is 1115GLSB and the station numbers are listed in Table 1 for Niagara, Rochester and Oswego. Appendix A contains a microfiche of the data base.

Segmentation

In order to reflect the regional differences in water quality and to facilitate the presentation of findings, each study area was sub-divided into a source area (river), a mixing area (harbor), and a nearshore area (adjacent to the open waters of Lake Ontario).

The water quality of the rivers was greatly different from that of the lake, and the combined average values of measurements without the separation of these water sources would be misleading. This segmentation has been viewed as a convenient, efficient, understandable and objective way of analyzing and presenting a large volume of data (Upper Lakes Reference Group IJC 1976).

In order to determine which stations belonged within each segment, a cluster analysis of the conductivity data was performed using PROC CLUSTER of the Statistical Analysis System (SAS 1982). This procedure uses a hierarchical clustering technique, Ward's method (Milligan 1980), that organizes the data so that one cluster of data may be entirely contained within another cluster. Any other kind of overlap between clusters is disallowed. In the clustering procedure, each observation begins as a cluster by itself, after which like clusters are merged. The "distance" between two clusters is the sum of squares between the two clusters. New levels of clusters are generated by mimimizing the within-cluster sum of squares all over positions that can be obtained by merging two clusters from the previous level of clusters.

The Cubic Clustering Criteria (CCC) as defined (SAS 1982) was used for determining the "correct" number of clusters. Although values of the CCC that are greater than 2 or 3 indicate good clustering, we chose to ignore values that were less than 2.751, thus opting for a more conservative clustering of the data. The segments selected for each area are presented in Table 4, and displayed in Figures 2-4.

Table 4 Station Segmentation For Each Study Area

Niagara Plume	Stations
Lake Area	6,7,8,9,12,15,16,19
Mixing Area	2,3,4,5,10,11,13,14,17,18,20,21,22
Source Area	1
Rochester Embayment	
Lake Area	1,2,3,4,6,7,9,10,12,13,16,17,18,19,20,24, 25,26,29
Mixing & Nearshore Area	1A,5,8,11,14,15,27,28,51,52,53,54,55, 57,58,59,60,61,62,63,64,70
Source Area	21,56
Oswego Harbor	
Lake Area	12A,13A,17,19,29
Outer Harbor Area	9,11,22A,23
Inner Harbor Area	4,5,7,28,37
Source Area	3

RESULTS

Average values for selected parameters based on the cluster analysis for each area and survey are presented in Tables 5-14. Results are reported separately for the epilimnion, metalimnion, and hypolimnion data from the stratified period. These layers were determined by inspection of the temperature profiles within each area segment using the stations involved. The average of all samples from an area are reported under the category "All." Surface samples from the 1 meter depth are reported as "Surface."

THERMAL STRUCTURE

Thermal conditions in Lake Ontario during the April-May survey reflected several different early spring conditions. The water temperatures were the coldest in Niagara River Plume area reflecting ice out conditions in the Niagara River (Tables 5-7). The Rochester Embayment had a well developed thermal bar, while Oswego Harbor was entirely within the thermal bar.

In the Niagara River Plume study area, all water temperatures were below 4°C, but no inverse thermal stratification was observed. In the Rochester Embayment, a thermal bar was located between the outer station transect and the middle transect (Figure 6). In the mixing area of the Genessee River at Rochester New York, and in the Oswego Harbor area, all water temperatures were above 4°C but no thermal stratification was found.

By the second survey, a thermocline had developed between the 5 and 10 meter depths in the lake areas. Surface water temperatures were above 20°C in most areas. During the third survey the thermocline was between the 8 and 16 meter depths. The mixing and nearshore areas were no longer completely stratified, the water mass being primarily from the epilimnion. During the fourth survey, the thermocline was between the 25 and 33 meter depths. Only the lake areas in the Niagara River Plume and the Rochester Embayment remained completely stratified during the fourth survey.

NIAGARA RIVER PLUME - NEARSHORE STUDY
SOURCE AREA
NIAGARA STATION (01)

Table 5

Depths	Temp. (°C)	P Total (ug/l)	P T. Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1		April 22-25 1981				
All	1.2+0.1(11)	19.5+2.1(6)	5.4+0.5(7)	2.3+0.6(6)	24+ 3(8)	0.28+0.01(9)	16.1+0.1(11)	23.3+0.2(11)
Surface	1.2+0.2(3)	20.4+5.7(2)	5.2+0.6(2)	1.1 (1)	24+11(2)	0.26+0.01(2)	16.0+0.3(3)	23.3+0.3(3)
0-20M	Same As All							
20M-Bottom								
		Survey 2		August 2-5 1981				
All	22.8+0.0(12)	11.3+0.3(12)	5.9+0.6(12)	2.5+0.1(12)	110+ 1(12)	0.11+0.00(12)	18.1+0.3(12)	24.7+0.2(4)
Surface	22.8+0.1(3)	11.2+0.8(3)	5.5+0.7(3)	2.3+0.2(3)	110+ 3(3)	0.11+0.01(3)	18.1+0.8(3)	24.3 (1)
EPI	Same As All							
META								
HYPO								
		Survey 3		August 30-Sept 2 1981				
All	21.9+0.1(12)	9.0+0.9(11)	4.7+0.2(9)	3.3+0.5(6)	79+ 8(12)	0.08+0.00(12)	18.0+0.1(6)	24.4+2.3(3)
Surface	21.9+0.2(4)	9.5+2.2(4)	5.0+0.0(3)	3.5+1.5(2)	80+15(4)	0.08+0.01(4)	17.9+0.2(2)	25.8 (1)
EPI	Same As All							
META								
HYPO								
		Survey 4		October 8-10 1981				
All	13.1+0.0(6)	31.6+6.0(6)	6.3+0.5(6)	2.9+0.6(6)	132+ 5(6)	0.11+0.00(5)	18.4+0.1(6)	25.8+0.3(2)
Surface	13.1+0.1(3)	29.0+6.6(3)	5.9+0.3(3)	3.1+1.0(3)	132+ 7(3)	0.11+0.00(2)	18.4+0.2(3)	26.1 (1)
EPI	Same As All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of samples). "Depths" refers to water layers sampled: "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Niagara River Plume - Nearshore Study
Source Area
Niagara Station (01)

Table 5 Con't

Depths	Chloro-phyll-a (ug/l)	TKN (mg N/l)	NH_3, Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1			April 22-25 1981			
All	4.0 (1)		34.0+1.9(10)	262+1(11)	84.2+0.6(11)	8.16+0.11(11)	4.5+0.3(11)	1.4+0.1(2)
Surface	4.0 (1)		37.5+8.5(2)	262+1(3)	85.7+1.3(3)	8.41+0.41(3)	4.3+0.5(3)	
0-20M			Same as All					
20M-Bottom								
		Survey 2			August 2-5 1981			
All	1.0+0.2(2)		19.0+2.5(12)	284+1(12)	93.8+0.1(12)	8.54+0.02(12)	1.4+0.0(12)	3.8+0.2(3)
Surface	1.0+0.2(2)		18.7+5.3(3)	284+1(3)	93.7+0.3(3)	8.50+0.07(3)	1.3+0.0(3)	
EPI			Same as All					
META								
HYPO								
		Survey 3			August 30-Sept 2 1981			
All	2.1+0.1(4)	0.40+0.09(4)	12.5+3.3(12)	287+0(12)	94.8+0.2(12)	8.44+0.03(12)	1.4+0.0(12)	3.4+0.2(3)
Surface	2.1+0.1(4)	0.25+0.02(2)	11.5+6.2(4)	287+0(4)	94.8+0.2(4)	8.43+0.06(4)	1.4+0.1(4)	
EPI			Same as All					
META								
HYPO								
		Survey 4			October 8-10 1981			
All	0.23+0.2(3)	0.32+0.04(4)	24.5+1.6(6)	295+1(6)	96.1+0.2(6)	8.26+0.02(6)	7.9+1.5(6)	0.8+0.2(3)
Surface	0.23+0.2(3)	0.31+0.05(3)	24.3+2.3(3)	294+1(3)	96.2+0.3(3)	8.26+0.03(3)	7.6+2.1(3)	
EPI			Same as All					
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Niagara River Plume - Nearshore Study
Mixing Area
Niagara Stations (02,03,04,05,10,11,13,14,17,18,20,21,22)

Table 6

Depths	Temp. (°C)	P Total (ug/l)	P T. Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss. Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1		April 22-25 1981				
All	2.0+0.1(80)	18.6+0.5(82)	5.5+0.2(85)	1.7+0.1(77)	48+2(85)	0.29+0.00(85)	17.5+0.3(82)	24.5+0.1(82)
Surface	1.9+0.2(36)	19.0+0.7(37)	5.3+0.2(37)	1.8+0.1(34)	46+3(38)	0.29+0.01(38)	17.6+0.4(37)	24.6+0.2(37)
0-20M			Same as All					
20M-Bottom								
		Survey 2		August 2-5 1981				
All	22.1+0.1(92)	18.1+1.6(92)	6.4+0.3(92)	2.8+0.2(89)	117+4(84)	0.11+0.01(84)	25.3+3.4(88)	24.7+0.2(29)
Surface	22.5+0.1(40)	16.2+0.8(40)	6.1+0.4(40)	3.0+0.5(39)	109+2(37)	0.11+0.00(37)	20.3+0.5(39)	24.6+0.4(14)
EPI	21.2+0.1(90)	18.1+1.7(90)	6.4+0.3(90)	2.7+0.2(87)	117+4(84)	0.11+0.01(84)	25.4+3.5(86)	24.7+ .3(27)
META	17.9+0.6(2)	17.1+0.1(2)	6.5+0.3(2)	3.2+1.8(2)	No data	No data	21.3+1.5(2)	No data
HYPO								
		Survey 3		August 30-Sept 3 1981				
All	21.1+0.2(90)	12.6+0.6(87)	5.0+0.4(63)	3.3+0.2(25)	67+4(80)	0.09+0.00(83)	20.8+0.3(63)	26.1+0.7(30)
Surface	21.4+0.4(38)	12.2+1.0(37)	4.5+0.3(28)	3.4+0.3(11)	68+5(35)	0.09+0.00(36)	19.8+0.4(26)	25.2+1.1(13)
EPI	Same as All							
META								
HYPO								
		Survey 4		October 8-10 1981				
All	12.5+0.0(77)	23.8+2.9(77)	5.1+0.3(73)	2.3+0.3(73)	122+2(77)	0.13+0.00(77)	21.1+0.3(77)	27.4+0.3(25)
Surface	12.6+0.1(40)	21.0+1.3(40)	5.3+0.4(37)	2.6+0.5(38)	122+3(40)	0.13+0.00(40)	20.5+0.4(40)	27.2+0.4(13
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled: "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Niagara River Plume - Nearshore Study
Mixing Area
Niagara Stations (02,03,04,05,10,11,13,14,17,18,20,21,22)

Table 6 Con't

Depths	Chloro-phyll-a (ug/l)	TKN (mg N/l)	NH_3, Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
			Survey 1		April 22-25 1981			
All	3.8+0.1(24)	No data	39.4+2.0(80)	272+1(88)	85.5+0.4(88)	8.09+0.01(88)	3.5+0.1(87)	1.7+0.1(32)
Surface	3.8+0.1(24)		41.3+3.9(36)	270+2(39)	85.4+0.6(39)	8.08+0.01(39)	3.6+0.1(39)	
0-20M	SAME AS ALL							
20M-Bottom								
			Survey 2		August 2-5 1981			
All	3.6+0.3(30)	No data	27.8+4.8(83)	292+1(92)	93.4+0.1(92)	8.54+0.01(92)	1.8+0.1(92)	3.2+0.1(39)
Surface	3.6+0.3(30)		24.3+2.0(38)	290+1(40)	93.4+0.2(40)	8.56+0.01(40)	1.7+0.1(40)	
EPI			28.4+4.9(81)	292+1(90)	93.4+0.1(90)	8.54+0.01(90)	1.8+0.1(90)	
META			4.5+3.5(2)	310+4(2)	93.5+0.5(2)	8.35+0.01(2)	2.3+0.0(2)	
HYPO								
			Survey 3		August 30-Sept 2 1981			
All	3.7+0.4(34)	0.49+0.07(48)	13.8+1.3(77)	295+1(93)	92.5+0.3(93)	8.42+0.01(93)	1.4+0.0(92)	3.7+0.1(39)
Surface	3.7+0.4(34)	0.45+0.09(34)	14.0+2.4(33)	291+1(39)	93.5+0.3(39)	8.45+0.02(39)	1.3+0.0(39)	
EPI	SAME AS ALL							
META								
HYPO								
			Survey 4		October 8-10 1981			
All	2.0+0.1(34)	0.22+0.01(52)	32.8+7.8(75)	305+1(77)	93.4+1.1(77)	8.26+0.01(77)	4.6+0.3(77)	1.9+0.2(39)
Surface	2.0+0.1(34)	0.21+0.01(38)	35.5+11.4(39)	303+2(40)	94.8+0.3(40)	8.27+0.01(40)	4.8+0.5(40)	
EPI	SAME AS ALL							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled: "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Niagara River Plume - Nearshore Study
Lake Area
Niagara Station (06,07,08,09,12,15,16,19)

Table 7

Depths	Temp. (°C)	P Total (ug/l)	P T. Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss. Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1			April 22-25 1981			
All	3.0+0.0(114)	14.5+1.4(111)	6.1+0.2(111)	3.2+0.1(90)	152+4(112)	0.32+0.00(112)	25.0+0.2(107)	27.9+0.5(107)
Surface	2.9+0.1(22)	11.9+0.5(22)	6.0+0.4(21)	3.1+0.3(19)	146+8(22)	0.32+0.01(22)	24.6+0.6(21)	27.0+0.5(21)
0-20M	2.9+0.0(91)	11.6+0.2(88)	6.0+0.2(87)	3.1+0.2(72)	151+4(89)	0.32+0.00(89)	25.0+0.2(85)	28.1+0.6(85)
20M-Bottom	3.0+0.1(23)	25.7+6.5(23)	6.7+0.6(22)	3.5+0.3(18)	155+8(23)	0.32+0.01(23)	25.0+0.8(22)	27.3+0.9(22)
		Survey 2			August 2-5 1981			
All	13.7+0.9(64)	16.9+1.8(64)	6.4+0.3(59)	2.9+0.2(62)	149+16(62)	0.19+0.01(64)	23.4+0.5(59)	25.3+0.3(37)
Surface	21.5+0.3(13)	18.5+1.4(13)	6.0+0.4(12)	1.9+0.3(12)	97+ 7(12)	0.14+0.01(13)	21.3+0.8(12)	24.8+0.4(8)
EPI	20.6+0.3(31)	17.9+0.8(31)	6.1+0.2(28)	2.2+0.2(29)	115+14(30)	0.15+0.01(31)	21.9+0.6(29)	25.2+0.3(19)
META	13.3+0.4(8)	27.7+13.9(8)	6.2+0.3(8)	2.4+0.4(8)	79+11(8)	0.17+0.02(8)	25.7+1.4(7)	26.1+0.6(4)
HYPO	5.2+0.4(25)	12.1+0.8(25)	6.9+0.7(23)	3.7+0.5(25)	215+35(24)	0.24+0.03(25)	24.5+0.8(23)	25.0+0.5(14)
		Survey 3			August 30-Sept 2 1981			
All	12.6+0.9(55)	10.9+0.7(53)	5.2+0.3(43)	3.0+0.4(25)	197+28(49)	0.23+0.02(52)	24.7+0.7(20)	30.1+0.5(10)
Surface	21.2+0.2(11)	13.6+1.4(11)	4.9+0.3(10)	2.1+0.2(7)	68+ 8(10)	0.09+0.00(11)	18.9+0.4(4)	27.4+0.1(2)
EPI	20.3+0.2(22)	12.7+1.1(22)	4.9+0.3(17)	2.6+0.3(14)	75+ 6(20)	0.11+0.01(22)	22.0+1.2(8)	28.9+0.9(4)
META	12.6+0.3(11)	7.4+0.7(10)	4.2+0.5(8)	2.7+0.4(6)	134+19(10)	0.27+0.01(11)	26.1+0.2(4)	30.7+0.0(2)
HYPO	4.9+0.2(22)	10.7+1.2(21)	5.9+0.6(18)	4.7+2.1(5)	359+52(19)	0.35+0.01(19)	26.7+0.1(8)	31.0+0.1(4)
		Survey 4			October 8-10 1981			
All	8.8+0.5(50)	16.8+2.0(50)	7.4+0.5(49)	4.0+0.5(47)	249+23(50)	0.28+0.01(50)	25.8+0.1(50)	29.3+0.1(30)
Surface	12.3+0.2(11)	12.9+0.5(11)	4.5+0.3(11)	1.7+0.3(11)	97+ 4(11)	0.17+0.00(11)	25.1+0.3(11)	29.1+0.2(7)
EPI	12.2+0.1(22)	12.2+0.5(22)	4.8+0.3(22)	2.1+0.3(22)	106+ 4(22)	0.18+0.00(22)	25.3+0.1(22)	29.1+0.1(14)
META	8.7+0.3(8)	9.9+0.6(8)	6.1+0.7(7)	3.5+0.9(8)	278+31(8)	0.34+0.01(8)	26.0+0.1(8)	29.5+0.2(4)
HYPO	5.0+0.1(20)	24.6+4.5(20)	10.6+0.8(20)	6.6+0.7(17)	395+32(20)	0.36+0.01(20)	26.4+0.1(20)	29.4+0.1(12)

Results are reported as mean + Standard Error (Number of Samples). "Depths" refers to water layers sampled: "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Niagara River Plume - Nearshore Study
Lake Area
Niagara Stations (06,07,08,09,12,15,16,19)

Table 7 Con't

Depths	Chlorophyll-a (ug/l)	TKN (mg N/l)	NH_3, Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbdity NTU	Secchi Disk (m)
		Survey 1			April 22-25 1981			
All	2.5+0.2(21)	No Data	8.7+1.7(90)	323+1(112)	93.6+0.2(112)	8.11+0.01(112)	3.8+1.2(109)	5.2+0.4(23)
Surface	2.5+0.2(20)		13.8+8.3(17)	321+2(21)	93.2+0.5(21)	8.11+0.02(21)	4.5+3.4(21)	
0-20M	2.5+0.2(21)		9.7+2.1(72)	322+1(89)	93.4+0.2(89)	8.11+0.01(89)	4.1+1.5(88)	
20M-Bottom			4.9+0.9(18)	326+1(23)	94.3+0.4(23)	8.11+0.02(23)	2.4+0.6(21)	
		Survey 2			August 2-5 1981			
All	3.2+0.4(12)	No Data	25.8+2.7(55)	314+2(64)	94.1+0.3(64)	8.27+0.04(64)	1.7+0.1(63)	2.7+0.2(13)
Surface	3.7+0.3(9)		17.6+3.9(11)	295+3(13)	93.4+1.0(13)	8.51+0.09(13)	1.9+0.2(13)	
EPI	3.7+0.3(10)		23.8+3.0(27)	299+2(31)	92.8+0.5(31)	8.51+0.04(31)	1.9+0.1(31)	
META			39.8+8.6(6)	321+2(8)	93.6+0.4(8)	8.22+0.01(8)	1.8+0.1(8)	
HYPO	0.8+0.1(2)		24.3+4.9(22)	330+0(25)	95.9+0.4(25)	8.00+0.02(25)	1.5+0.1(24)	
		Survey 3			August 30-Sept 2 1981			
All	3.7+0.4(11)	0.48+0.04(27)	5.7+1.1(40)	317+2(55)	93.9+0.4(55)	8.11+0.04(55)	1.4+0.1(54)	4.1+0.1(11)
Surface	3.7+0.4(11)	0.39+0.07(9)	12.5+3.5(8)	295+2(11)	92.4+0.6(11)	8.47+0.05(11)	1.1+0.1(11)	
EPI	3.7+0.4(11)	0.46+0.06(13)	9.2+2.1(16)	301+2(22)	91.4+0.5(22)	8.40+0.04(22)	1.2+0.0(22)	
META		0.57+0.07(4)	3.9+2.4(7)	323+1(11)	93.3+0.4(11)	7.96+0.02(11)	1.0+0.1(11)	
HYPO		0.48+0.07(10)	3.0+1.2(17)	331+1(22)	96.8+0.3(22)	7.90+0.01(22)	1.8+0.2(21)	
		Survey 4			October 8-10 1981			
All	1.5+0.3(9)	0.22+0.01(36)	5.4+0.4(50)	330+1(50)	93.8+0.3(50)	8.06+0.03(50)	1.6+0.3(50)	4.9+0.1(11)
Surface	1.5+0.3(9)	0.22+0.02(11)	7.5+0.3(11)	321+1(11)	91.2+0.2(11)	8.27+0.03(11)	0.9+0.1(11)	
EPI	1.5+0.3(9)	0.23+0.02(18)	8.0+0.4(22)	322+1(22)	91.4+0.1(22)	8.25+0.02(22)	0.9+0.1(22)	
META		0.22+0.02(5)	4.0+0.5(8)	331+1(8)	94.5+0.3(8)	7.98+0.03(8)	0.8+0.1(8)	
HYPO		0.22+0.02(13)	3.2+0.5(20)	337+1(20)	96.2+0.2(20)	7.90+0.02(20)	2.7+0.7(20)	

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Study
Source Area
Rochester Stations (21,56)

Table 8

Depths	Temp (°C)	P Total (ug/l)	P T.Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1		April 29-May 4 1981				
All	11.4+0.7(4)	43.2+ 8.9(3)	9.6+2.7(4)	4.8+ 2.6(4)	605+374(4)	0.38+0.04(4)	32.2+3.9(3)	45.1(14.1(3)
Surface	11.8+0.8(3)	46.9+14.2(2)	9.5+3.8(3)	4.7+ 3.6(3)	648+526(3)	0.39+0.06(3)	35.2+4.2(2)	48.1+23.8(2)
40M-Bottom	10 (1)	35.9 (1)	9.7 (1)	5.0 (1)	475 (1)	0.36 (1)	26 (1)	39 (1)
		Survey 2		July 21-30 1981				
All	21.5 0.6(9)	26.9+ 4.5(10)	8.7+1.6(10)	5.1+ 2.6(10)	183+ 79(8)	0.14+ .04(10)	28.4+1.4(10)	34.9+2.0(4)
Surface	21.7+0.5(6)	31.1+ 5.6(7)	8.8+2.2(7)	5.9+ 4.1(7)	214+104(6)	0.17+0.05(7)	29.6+1.9(7)	36.0+2.5(3)
EPI	Same as All							
META								
HYPO								
		Survey 3		August 18-26 1981				
All	21.2+0.2(8)	50.9+ 9.0(8)	15.6+4.3(5)	12.0+ 7.0(5)	439+163(8)	0.20+0.06(8)	30.7+7.3(2)	29.7 (1)
Surface	21.1+0.4(5)	60.4+12.3(5)	14.0+3.2(3)	14.0+11.8(3)	528+255(5)	0.21+0.09(5)	38.1 (1)	
EPI	Same as All							
META								
HYPO								
		Survey 4		September 30-Oct 1 1981				
All	14.1+0.4(9)	76.0+15.9(9)	23.1+4.5(9)	19.8+ 4.6(8)	445+274(3)	0.56+0.09(8)	53.0+8.6(9)	61.4+7.0(7)
Surface	14.1+0.5(6)	57.4+19.3(6)	16.7+4.8(6)	13.0+ 4.8(5)	445+274(3)	0.45+0.12(5)	43.1+8.3(6)	53.0+10.0(4)
EPI	Same as All							
META								
HYPO								

Results are reported as mean $\pm$ Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Study
Source Area
Rochester Stations (21,56)

Table 8 Con't

Depths	Chlorophyll-a (ug/l)	TKN (mg N/l)	NH_3, Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1		April 29-May 4 1981				
All	5.1+2.3(2)	No Data	144+ 90(4)	411+27(4)	97.8+1.5(4)	8.21+0.10(4)	13.1+4.3(4)	0.3 (1)
Surface	5.1+2.3(2)	No Data	141+128(3)	421+36(3)	99.0+1.2(3)	8.24+0.13(3)	12.9+6.1(3)	
4 M-Bottom	No Data	No Data	155 (1)	380 (1)	94 (1)	8.14 (1)	13.5 (1)	
		Survey 2		July 21-30 1981				
All	5.7+0.5(5)	0.43+ .14(3)	39.2+11.3(10)	342+20(9)	87.6+0.9(9)	8.40+0.03(9)	3.8+0.9(9)	1.6+0.2(6)
Surface	5.7+0.5(5)	0.43+ .14(3)	28.2+12.6(7)	357+28(6)	88.3+1.2(6)	8.39+ .04(6)	4.6+1.2(6)	
EPI	Same as All							
META								
HYPO								
		Survey 3		August 18-26 1981				
All	12.7+1.7(5)	0.55+0.09(4)	27.9+12.4(5)	465+45(8)	101.8+3.9(8)	8.33+0.10(8)	5.0+0.9(8)	1.1+0.2(5)
Surface	12.7+1.7(5)	0.57+0.13(3)	10.8+ 8.0(3)	507+64(5)	105.2+5.5(5)	8.34+0.15(5)	5.6+1.2(5)	
EPI	Same as All							
META								
HYPO								
		Survey 4		September 23-Oct 1 1981				
All	6.1+2.7(4)	0.55+0.08(7)	138.6+33.7(8)	500+50(9)	117.9+6.6(9)	8.14+0.04(9)	16.9+4.4(9)	1.2+0.2(6)
Surface	6.1+2.1(4)	0.53+0.08(6)	97.6+40.7(5)	434+52(6)	108.5+7.0(6)	8.19+0.05(6)	12.0+4.6(6)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Study Area
Mixing and Nearshore Area
Rochester Stations (01A,5,8,11,14,15,27,28,51,52,53,54,55,57,58,59,60,61,62,63,64,70)

Table 9

Depths	Temp (°C)	P Total (ug/l)	P T. Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1			April 29-May 4 1981			
All	7.8+0.2(44)	16.3+0.8(43)	6.2+0.1(44)	1.4+0.1(40)	65+13(44)	0.28+0.003(44)	23.4+0.7(41)	28.5+0.5(40)
Surface	8.1+0.4(21)	17.8+1.6(21)	6.3+0.2(21)	1.6+0.2(19)	83+26(21)	0.28+0.01 (21)	22.8+0.4(19)	28.9+0.8(19)
0-20M	7.8+0.2(44)	16.4+0.8(43)	6.2+0.1(44)	1.4+0.1(40)	66+13(44)	0.28+0.003(44)	23.4+0.7(41)	28.5+0.5(40)
20M-Bottom	5.6+0.1(4)	14.6+0.1(4)	6.2+0.1(4)	1.8+0.5(4)	56+ 3(4)	0.29+ .00 (4)	22.2+0.6(4)	27.4+0.7(4)
		Survey 2			July 21-30 1981			
All	18.3+0.4(158)	20.0+0.8(155)	7.3+0.5(155)	2.6+0.2(142)	107+ 6(139)	0.13+0.01 (149)	26.2+0.2(149)	30.3+0.6(52)
Surface	20.6+0.3(68)	22.1+1.6(67)	8.2+0.9(67)	2.5+0.3(60)	96+10(59)	0.10+0.01 (62)	26.3+0.4(63)	30.1+1.0(22)
EPI	21.3+0.1(110)	22.1+1.1(107)	8.0+0.7(108)	2.6+0.2(96)	88+ 7(96)	0.09+0.004(103)	26.1+0.3(101)	30.3+0.6(51)
META	12.9+0.6(38)	15.8+0.7(38)	5.5+0.3(37)	2.4+0.3(37)	126+ 9(34)	0.19+0.02 (37)	26.1+0.1(38)	31.0 (1)
HYPO	5.3+0.2(10)	13.7+1.2(10)	6.7+0.8(10)	3.3+0.8(9)	235+16(9)	0.34+0.01 (9)	28.2+1.7(10)	
		Survey 3			August 18-26 1981			
All	20.4 0.2(144)	19.8+0.9(113)	9.6+0.7(94)	2.7+0.3(101)	94+ 4(132)	0.10+0.005(124)	24.2+0.3(46)	29.2+0.4(47)
Surface	21.3+0.1(62)	19.2+1.0(50)	8.9+0.8(43)	2.4+0.5(46)	93+ 7(59)	0.09+0.01 (55)	23.9+0.3(19)	28.7+0.6(19)
EPI	Same as All							
META								
HYPO								
		Survey 4			September 23-Oct 1 1981			
All	14.7+0.1(134)	28.3+1.6(133)	8.6+0.6(133)	3.9+0.3(119)	168+14(123)	0.15+0.01 (128)	26.5+0.6(125)	30.0+0.9(45)
Surface	14.7+0.1(66)	27.6+2.0(66)	8.8+1.1(66)	3.6+0.3(59)	160+21(60)	0.15+0.01 (63)	26.2+0.9(61)	29.4+1.2(21)
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Study Area
Mixing and Nearshore Area
Rochester Stations (01A,5,8,11,14,15,27,28,51,52,53,54,55,57,58,59,60,61,62,63,64,70)

Table 9 Con't

Depths	Chlorophyll-a (ug/l)	TKN (mg N/l)	NH_3, Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1			April 29-May 4 1981			
All	4.7+0.1(17)	No Data	21.5+6.2(40)	316+3(44)	91.7+0.2(43)	8.33+0.03(43)	2.5+0.5(43)	3.2+0.3(18)
Surface	4.7+0.1(17)	No Data	25.6+7.5(19)	316+3(21)	91.7+0.3(21)	8.33+0.03(21)	3.1+0.9(21)	
0-20M	4.7+0.1(17)	No Data	21.5+6.2(40)	316+3(44)	91.7+0.2(43)	8.33+0.03(43)	2.5+0.5(43)	
10M-Bottom	No Data	No Data	3.8 (2)	307+1(4)	91.3+0.6(4)	8.32+0.02(4)	1.2+0.1(4)	
		Survey 2			July 21-30 1981			
All	5.0+0.4(41)	0.40+0.02(35)	28.1+1.7(146)	315+1(158)	89.1+0.4(158)	8.27+0.02(158)	2.1+0.1(158)	2.4+0.1(61)
Surface	5.0+0.8(41)	0.41+0.03(18)	26.5+2.7(63)	315+3(68)	88.1+0.5(68)	8.34+0.02(68)	2.2+0.2(68)	
EPI	5.2+0.4(37)	0.39+0.02(34)	28.6+2.1(104)	312+2(110)	87.5+0.4(110)	8.35+0.02(110)	2.2+0.1(110)	
META	3.9+0.7(3)	No Data	27.9+3.3(34)	320+1(38)	91.4+0.6(38)	8.09+0.02(38)	1.8+0.1(38)	
HYPO	3.6 (1)	0.85 (1)	23.4+6.3(8)	330+1(10)	98.1+0.8(10)	7.96+0.01(10)	1.9+0.2(10)	
		Survey 3			August 18-26 1981			
All	5.2+0.3(58)	0.43+0.03(52)	16.4+1.3(86)	307+1(143)	89.3+0.3(143)	8.37+0.02(143)	1.8+0.1(143)	2.7+0.1(62)
Surface	5.3+0.3(57)	0.40+0.03(43)	14.3+1.6(38)	306+2(62)	88.6+0.5(62)	8.44+0.04(62)	1.8+0.1(62)	
EPI	Same as All							
META								
HYPO								
		Survey 4			September 23-Oct 1 1981			
All	5.1+0.2(59)	0.33+0.01(84)	15.8+2.1(125)	321+3(134)	92.1+0.4(134)	8.31+0.01(134)	2.5+0.3(134)	3.0+0.1(63)
Surface	5.1+0.2(59)	0.33+0.01(62)	14.4+2.6(62)	319+4(66)	91.7+0.5(66)	8.32+0.01(66)	2.4+0.4(66)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; 0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Area
Lake Area
Rochester Stations (01,02,03,04,06,07,09,10,12,13,16,17,18,19,20,24,25,26,29)

Table 10

Depths	Temp (°C)	P Total (ug/l)	P T. Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
	Survey 1				April 29-May 4 1981			
All	4.2+0.1(56)	13.8+0.3(55)	7.7+0.2(55)	3.9+0.2(50)	124+ 6(55)	0.31+0.003(55)	25.1+0.2 (55)	29.3+0.2 (55)
Surface	4.3+0.3(19)	14.3+0.7(19)	7.7+0.3(18)	3.8+0.4(17)	121+11(19)	0.31+0.004(19)	25.1+0.3 (19)	29.0+0.2 (19)
0-20M	4.6+0.2(25)	14.3+0.6(25)	7.5+0.2(24)	3.4+0.4(23)	109+10(25)	0.31+0.004(25)	24.7+0.3 (25)	28.9+0.2 (25)
20M-Bottom	3.9+0.1(31)	13.5+0.1(30)	7.9+0.2(31)	4.4+0.3(27)	137+ 5(30)	0.32+0.003(30)	25.4+0.1 (30)	29.7+0.4 (30)
	Survey 2				July 21-30 1981			
All	12.9+0.5(253)	16.1+2.0(252)	6.3+0.2(249)	3.9+0.3(211)	129+ 8(241)	0.19+0.01 (245)	26.0+0.1 (228)	28.6+0.2 (93)
Surface	20.9+0.2(53)	25.1+9.2(53)	5.6+0.2(51)	2.0+0.3(44)	49+ 7(51)	0.07+0.01 (52)	25.8+0.1 (50)	27.4+0.5 (19)
EPI	21.0+0.1(103)	20.1+4.7(103)	5.6+0.2(100)	2.1+0.4(86)	46+ 4(98)	0.06+0.01 (100)	25.7+0.1 (96)	27.7+0.3 (41)
META	12.8+0.3(53)	16.2+0.2(53)	5.1+0.2(53)	2.6+0.3(45)	78+ 8(51)	0.16+0.01 (51)	26.0+0.1 (49)	28.6+0.5 (19)
HYPO	4.5+0.1(97)	11.8+0.4(96)	7.6+0.3(96)	6.7+0.6(80)	245+12(92)	0.34+0.01 (94)	26.3+0.1 (83)	29.7+0.5 (33)
	Survey 3				August 18-26 1981			
All	12.8+0.5(263)	20.3+2.2(209)	7.9+0.6(186)	3.9+0.4(220)	151+ 8(253)	0.23+0.01 (251)	25.4+0.2 (87)	30.6+0.4 (87)
Surface	21.1+0.1(55)	26.3+5.5(47)	10.3+2.5(41)	1.5+0.2(46)	61+ 3(53)	0.08+0.003(52)	24.1+0.4 (18)	29.4+0.7 (18)
EPI	20.6+0.1(109)	21.7+3.1(90)	8.8+1.4(79)	1.5+0.1(89)	63+ 3(106)	0.09+0.004(103)	24.3+0.3 (36)	29.7+0.4 (36)
META	12.8+0.2(52)	14.5+2.8(39)	6.4+0.6(38)	3.1+0.3(45)	100+ 7(50)	0.26+0.01 (50)	25.8+0.4 (18)	30.5+0.6 (18)
HYPO	4.4+0.1(102)	21.5+4.2(80)	7.6+0.6(69)	6.5+1.0(86)	272+13(97)	0.36+0.004(98)	26.3+0.5 (33)	31.7+0.9 (33)
	Survey 4				September 30-Oct 1 1981			
All	11.2+0.3(215)	18.2+1.1(209)	8.7+0.4(209)	4.7+0.3(198)	164+ 9(208)	0.21+0.01 (204)	25.5+0.1 (173)	27.6+0.04(82)
Surface	14.7+0.1(53)	20.1+1.4(52)	8.3+0.9(52)	3.3+0.3(50)	97+ 3(51)	0.15+ .004(51)	24.9+0.1 (42)	27.4+0.1 (19)
EPI	14.2+0.1(142)	17.7+0.4(140)	7.4+0.4(140)	3.3+0.3(132)	102+ 3(136)	0.16+ .003(136)	25.1+0.04(115)	27.4+0.04(51)
META	8.9+0.3(16)	14.2+1.9(15)	7.7+1.2(15)	5.6+1.1(12)	190+14(16)	0.29+ .01 (16)	25.9+0.1 (12)	27.7+0.1 (7)
HYPO	4.4+0.1(57)	20.5+0.4(54)	12.1+1.0(54)	8.2+0.7(54)	308+22(56)	0.34+ .01 (52)	26.4+0.03(46)	28.0+0.1 (24)

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Rochester Embayment Nearshore Area
Lake Area
Rochester Stations (01,02,03,04,06,07,09,10,12,13,16,17,18,19,20,24,25,26,29)

Table 10 Con't

Depths	Chlorophyll-a (ug/l)	TKN (mg N/l)	NH_3 Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1		April 29-May 4 1981				
All	3.1+0.3(19)	No Data	4.8+0.4(54)	323+ 1(56)	93.0+0.2(56)	8.20+0.02(56)	2.6+1.5(55)	6.2+0.4(19)
Surface	3.1+0.3(18)	No Data	4.6+0.6(18)	323+ 2(19)	92.8+0.3(19)	8.18+0.05(19)	5.3+4.3(19)	
0-20M	3.1+0.3(18)	No Data	4.7+0.6(24)	321+ 2(25)	92.6+0.3(25)	8.21+0.04(25)	4.3+3.3(25)	
20M-Bottom	2.5 (1)	No Data	4.8+0.6(30)	324+ 1(31)	93.3+0.2(31)	8.19+0.01(31)	1.2+0.2(30)	
		Survey 2		July 21-30 1981				
All	2.9+0.2(35)	0.31+0.02(83)	24.0+1.7(246)	316+ 1(253)	92.0+0.4(253)	8.19+0.01(253)	1.5+0.03(253)	2.9+0.1(54)
Surface	2.9+0.2(35)	0.36+0.05(20)	15.9+1.4(51)	304+ 1(53)	86.2+0.4(53)	8.43+0.02(53)	1.7+0.05(53)	
EPI	3.0+0.2(34)	0.35+0.02(37)	20.3+1.7(100)	304+0.4(103)	85.9+0.2(103)	8.43+0.02(103)	1.7+0.04(103)	
META	1.2 (1)	0.34+0.03(17)	59.1+4.0(52)	318+ 1(53)	92.0+0.5(53)	8.13+0.02(53)	1.6+0.1 (53)	
HYPO		0.26+0.03(28)	8.5+1.3(94)	328+0.3(97)	98.5+0.5(97)	7.97+0.01(97)	1.2+0.1 (97)	
		Survey 3		August 18-26 1981				
All	5.4+1.1(51)	0.43+0.03(73)	14.1+1.1(191)	315+ 1(263)	90.2+0.7(263)	8.14+0.02(263)	1.4+0.1 (263)	3.2+0.1(57)
Surface	5.4+1.1(51)	0.49+0.04(42)	12.7+1.5(41)	301+ 1(55)	86.8+1.5(55)	8.52+0.01(55)	1.6+0.2 (55)	
EPI	5.4+1.1(51)	0.46+0.03(47)	17.6+1.3(80)	302+0.3(109)	86.6+1.1(109)	8.44+0.01(109)	1.5+0.1 (109)	
META		0.41+0.04(8)	23.4+3.0(38)	320+0.5(52)	90.9+1.7(52)	7.96+0.01(52)	1.1+0.03(52)	
HYPO		0.35+0.05(18)	5.5+1.3(73)	327+0.2(102)	93.6+1.2(102)	7.92+0.01(102)	1.4+0.1 (102)	
		Survey 4		September 23-Oct 1 1981				
All	4.6+0.2(52)	0.28+0.02(91)	11.0+2.5(209)	318+1.0(214)	92.8+0.2(214)	8.14+0.01(214)	1.1+0.1 (214)	4.5+0.1(54)
Surface	4.6+0.2(52)	0.34+0.03(50)	13.5+3.6(51)	312+0.3(53)	90.9+0.1(53)	8.30+0.01(53)	1.0+0.05(53)	
EPI	4.6+0.2(52)	0.31+0.03(71)	15.6+3.7(138)	313+0.3(141)	91.2+0.1(141)	8.26+0.01(141)	1.0+0.03(141)	
META		0.16+0.03(5)	3.6+0.5(15)	325+0.0(16)	94.4+0.2(16)	7.97+0.01(16)	0.9+0.1 (16)	
HYPO		0.16+0.02(15)	1.6+0.2(56)	330+0.4(57)	96.1+0.2(57)	7.91+0.01(57)	1.4+0.2 (57)	

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Source Area
Oswego Station (03)

Table 11

Depths	Temp. (°C)	P Total (ug/l)	P T.Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1			April 27-28 1981			
All	11.0+0.2(4)	66.0+11.9(4)	19.7+3.0(4)	5.3+1.1(3)	85+18(3)	0.36+0.01(3)	208.0+10.7(4)	68.8+0.1(4)
Surface	11.2+0.2(2)	67.5+11.5(2)	16.3+3.9(2)	3.0 (1)	92+27(2)	0.36+0.01(2)	218.6+21.4(2)	68.6+ 0(2)
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	19.8+0.9(6)	69.7+9.1(6)	23.2+3.2(6)	11.0+1.7(6)	535+125(4)	0.22+0.02(6)	50+ 0(4)	50+ 0(2)
Surface	21.5+0.9(3)	86.3+4.6(3)	26.2+4.8(3)	12.1+2.2(3)	725+145(2)	0.23+0.03(3)	50+ 0(2)	50 (1)
EPI	Same as All							
META								
HYPO								
		Survey 3			August 27-29 1981			
All	22.2+0.3(6)	86.2+1.9(6)	18.8+1.7(5)	11.4+0.7(4)	221+20(6)	0.11+0.00(6)	191+ 9(2)	71.3+1.1(2)
Surface	22.3+0.4(3)	86.3+3.3(3)	19.3+2.6(3)	11.5+1.5(2)	211+33(3)	0.10+0.00(3)	200 (1)	72.4+ (1)
EPI	Same as All							
META								
HYPO								
		Survey 4			October 2-5 1981			
All	12.6+0.2(6)	88.8+2.3(6)	41.4+2.1(6)	21.6+5.7(6)	648+117(6)	0.50+0.01(6)	189.5+14.6(6)	65.9+1.2(2)
Surface	12.5+0.3(3)	87.7+3.8(3)	39.3+1.2(3)	20.7+8.6(3)	540+235(3)	0.50+0.02(3)	188.3+24.1(3)	64.7 (1)
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Area
Source Area
Oswego Station (03)

Table 11 Con't

Depths	Chlorophyll-a (ug/l)	TKN (mg N/l)	NH_3 Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1		April 27-28 1981				
All	10.4+0.3(2)	No Data	188.5+8.7(4)	931+8.7(4)	103.2+1.4(4)	8.31+0.05(4)	5.4+0.1(4)	1.0+0,5(2)
Surface	10.4+0.3(2)		186.0+9.0(2)	931+ 15(2)	102.5+2.5(2)	8.26+0.10(2)	5.5+0.2(2)	
0-20M	Same as All							
20M-Bottom								
		Survey 2		July 30-August 1 1981				
All	9.5+2.8(2)	0.73+0.15(4)	60.5+6.5(6)	781+ 85(6)	91.2+0.4(6)	8.05+0.04(6)	4.2+0.6(6)	0.8+0.2(3)
Surface	9.5+2.8(2)	0.76+0.21(3)	60.7+ 5(3)	926+ 69(3)	90.8+0.7(3)	8.06+0.06(3)	5.0+0.7(3)	
EPI	Same as All							
META								
HYPO								
		Survey 3		August 27-29 1981				
All	21.2+1.5(3)	1.1 +0.2(2)	83.4+7.1(4)	1080+ 53(6)	94.8+0.7(6)	8.15+0.03(6)	4.5+0.2(6)	1.0+0.0(3)
Surface	21.2+1.5(3)	1.1 +0.2(2)	72.5+7.5(2)	1074+ 71(3)	94.3+0.7(3)	8.19+0.04(3)	4.6+0.3(3)	
EPI	Same as All							
META								
HYPO								
		Survey 4		October 2-5 1981				
All	11.9+0.1(2)	0.74+0.05(4)	104.0+2.0(6)	930+ 40(6)	103.1+1.1(6)	8.08+0.02(6)	4.6+0.2(6)	1.2+0.2(3)
Surface	11.9+0.1(2)	0.72+0.07(3)	103.7+3.2(3)	938+ 78(3)	102.5+1.9(3)	8.08+0.04(3)	4.7+0.5(3)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths" "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Inner Harbor Mixing Area
Oswego Stations (04,05,07,28,37)

Table 12

Depths	Temp. (°C)	P Total (ug/l)	P T.Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1			April 27-28 1981			
All	10.7+0.2(17)	60.4+3.9(17)	16.7+1.6(19)	4.6+0.4(11)	89+ 7(15)	0.37+0.03(15)	163.3+10.9(18)	57.1+2.8(17)
Surface	10.8+0.2(10)	55.6+5.6(10)	17.7+2.6(11)	5.1+0.5(7)	84+ 9(9)	0.39+0.06(9)	155.6+16.6(11)	55.4+3.8(11)
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	19.8+0.3(27)	50.8+4.5(27)	15.3+1.4(27)	5.8+0.7(27)	322+54(16)	0.17+0.01(25)	45.1+ 1.4(23)	44.6+2.7(9)
Surface	20.8+0.31(15)	62.7+6.3(15)	17.5+1.9(15)	6.5+1.0(15)	413+83(9)	0.17+0.02(14)	45.0+ 2.0(13)	43.6+3.9(5)
EPI	Same as All							
META								
HYPO								
		Survey 3			August 27-29 1981			
All	21.5+0.1(30)	47.1+2.9(29)	15.9+2.2(28)	7.9+1.4(24)	155+11(25)	0.10+0.00(29)	71.3+ 7.8(10)	40.5+2.4(10)
Surface	21.7+0.1(18)	47.1+3.6(18)	15.6+2.6(17)	5.0+0.8(14)	142+11(16)	0.09+0.00(18)	72.1+10.2(6)	38.6+2.5(6)
EPI	Same as All							
META								
HYPO								
		Survey 4			October 2-5 1981			
All	13.0 0.1(27)	64.2+3.7(27)	28.8+1.7(27)	16.6+2.6(27)	501+41(27)	0.37+0.02(27)	126.8+11.1(27)	59.5+4.3(9)
Surface	13.1+0.2(15)	56.7+4.4(15)	25.8 2.4(15)	14.6+3.2(15)	412+54(15)	0.34+0.03(15)	111.4+13.3(15)	52.6+6.2(5)
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Inner Harbor Mixing Area
Oswego Stations (04,05,07,28,37)

Table 12 Con't

Depths	Chloro-phyll-a (ug/l)	TKN (mg N/l)	NH_3 Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1			April 27-28 1981			
All	9.8+0.3(8)	No Data	211.0+31.8(17)	771+34(19)	102.0+0.4(19)	8.19+0.04(19)	5.0+0.3(19)	1.35+0.2(10)
Surface	9.8+0.3(8)		215.8+49.5(10)	733+51(11)	101.5+0.5(11)	8.15+0.07(11)	4.6+0.4(11)	
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	13.1+1.4(10)	0.59+0.05(17)	22.2+ 2.8(27)	611+44(27)	91.0+0.2(27)	8.27+0.03(27)	3.2+0.2(27)	1.5 +0.1(15)
Surface	13.1+1.4(10)	0.57+0.05(14)	21.8+ 3.7(15)	722+64(15)	90.8+0.3(15)	8.30+0.04(15)	3.7+0.3(15)	
EPI	Same as All							
META								
HYPO								
		Survey 3			August 27-29 1981			
All	13.0+1.2(15)	0.70+0.11(8)	45.7+ 6.5(15)	592+36(30)	90.4+0.4(30)	8.28+0.03(30)	2.6+0.1(30)	1.6 +0.1(15)
Surface	13.0+1.2(15)	0.70+0.11(8)	30.3+ 4.1(10)	618+49(18)	90.2+0.5(18)	8.32+0.05(18)	2.4+0.1(18)	
EPI	Same as All							
META								
HYPO								
		Survey 4			October 2-5 1981			
All	9.0+0.8(10)	0.61+0.03(20)	149.5+41.9(27)	731+40(27)	99.2+0.7(27)	8.12+0.02(27)	10.9+5.1(26)	1.9 +0.2(15)
Surface	9.0+0.8(10)	0.58+0.03(14)	189.2+74.8(15)	647+50(15)	97.9+1.0(15)	8.16+0.03(15)	9.4+6.2(15)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Outer Harbor Mixing Area
Oswego Stations (09,11,22A,23)

Table 13

Depths	Temp. (°C)	P Total (ug/l)	P T.Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1			April 27-28 1981			
All	9.1+0.2(15)	33.2+3.3(14)	15.3+2.3(12)	3.2+0.7(7)	43+ 9(15)	0.30+0.01(15)	75.0+11.2(14)	40.5+2.2(14)
Surface	9.1+0.3(8)	30.9+5.1(8)	12.9+2.4(7)	2.8+0.8(4)	42+16(8)	0.30+0.02(8)	69.6+18.7(8)	39.3+3.6(8)
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	18.2+0.3(23)	24.8+2.1(23)	8.0+0.6(23)	3.1+0.6(22)	141+14(15)	0.12+0.01(22)	38.7+ 1.9(21)	34.6+2.7(8)
Surface	19.0+0.3(12)	28.9+3.3(12)	8.4+0.9(12)	3.6+1.2(12)	136+16(8)	0.11+0.01(12)	41.8+ 2.5(11)	39.1+4.6(4)
EPI	Same as All							
META								
HYPO								
		Survey 3			August 27-29 1981			
All	20.5+0.2(21)	19.6+2.3(19)	7.2+1.2(20)	2.5+0.3(14)	82+ 4(19)	0.08+0.01(21)	44.0+ 4.7(7)	35.8+3.5(7)
Surface	20.8+0.1(12)	23.1+3.6(11)	8.1+1.9(11)	2.7+0.4(8)	80+ 6(11)	0.08+0.01(12)	51.4+ 5.5(4)	39.8+5.5(4)
EPI	Same as All							
META								
HYPO								
		Survey 4			October 2-5 1981			
All	13.3+0.1(21)	35.5+3.5(21)	14.2+1.8(21)	5.8+1.2(21)	320+58(20)	0.23+0.02(21)	64.9+ 7.8(21)	38.6+3.3(7)
Surface	13.3+0.1(12)	27.0+2.6(12)	9.7+1.5(12)	4.1+0.7(12)	238+69(12)	0.19+0.02(12)	46.4+ 6.5(12)	33.9+1.7(4)
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Outer Harbor Mixing Area
Oswego Stations (09,11,22A,23)

Table 13 Con't

Depths	Chloro-phyll-a (ug/l)	TKN (mg N/l)	NH_3 Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1			April 27-28 1981			
All	7.0+0.5(8)	No Data	100.9+27.3(15)	506+40(15)	98.0+0.4(15)	8.17+0.05(15)	3.0+0.2(15)	2.1+0.2(8)
Surface	7.0+0.5(8)		93.8+43.6(8)	479+70(8)	97.5+0.6(8)	8.24+0.02(8)	2.9+0.3(8)	
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	9.6+1.6(8)	0.44+0.04(13)	9.9+ 1.0(23)	385+18(23)	89.7+0.2(23)	8.44+0.03(23)	2.2+0.1(23)	2.3+0.1(12)
Surface	9.6+1.6(8)	0.40+0.04(9)	10.2+ 1.4(12)	399+30(12)	89.8+0.3(12)	8.47+0.05(12)	2.2+0.2(12)	
EPI	Same as All							
META								
HYPO								
		Survey 3			August 27-29 1981			
All	12.4+1.8(12)	0.54+0.03(6)	39.9+24.5(10)	363+10(21)	87.6+0.3(21)	8.47+0.04(21)	1.5+0.1(21)	2.4+0.2(12)
Surface	12.4+1.8(12)	0.54+0.03(6)	55.1+41.1(6)	382+14.1(12)	87.2+0.3(12)	8.51+0.05(12)	1.5+0.1(12)	
EPI	Same as All							
META								
HYPO								
		Survey 4			October 2-5 1981			
All	7.1+0.3(10)	0.46+0.02(17)	31.1+ 4.6(21)	469+30(21)	93.3+0.7(2)	8.18+0.04(21)	2.0+0.2(21)	3.3+0.3(12)
Surface	7.1+0.3(10)	0.45+0.03(12)	20.8+ 3.7(12)	395+24(12)	91.8+0.6(12)	8.20+0.05(12)	1.6+0.2(12)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Lake Area
Oswego Stations (12A,13A,17,19,29)

Table 14

Depths	Temp. (°C)	P Total (ug/l)	P T.Dissolved (ug/l)	P Soluble Reactive (ug/l)	Silica Diss.Reactive (ug Silicon/l)	NO_2+NO_3 Total (mg N/l)	Chloride Total (mg/l)	Sulfate Total (mg/l)
		Survey 1		April 27-28 1981				
All	9.0+0.4(18)	18.7+1.7(20)	10.2+1.3(20)	1.2+0.2(4)	14+ 2(20)	0.28+0.02(20)	31.5+2.1(20)	28.3+0.7(20)
Surface	9.2+0.5(9)	17.9+1.3(10)	8.4+0.8(10)	1.0+0.4(2)	14+ 3(10)	0.28+0.03(10)	31.6+3.4(10)	27.7+1.1(10)
0-20M	Same as All							
20M-Bottom								
		Survey 2		July 30-August 1 1981				
All	17.4+0.3(45)	17.2+0.5(45)	6.0+0.2(45)	3.1+0.5(44)	114+11(33)	0.13+0.01(43)	30.6+0.5(44)	29.8+0.2(15)
Surface	18.8+0.3(16)	18.6+1.0(16)	6.6+0.4(16)	2.6+0.3(15)	77+ 8(11)	0.10+0.01(15)	30.3+1.1(16)	29.8+0.3(5)
EPI	18.7+0.2(26)	18.2+0.7(26)	6.1+0.1(26)	3.5+0.9(25)	90+14(17)	0.10+0.01(24)	30.1+0.8(25)	29.8+0.3(6)
META	15.6+0.4(19)	15.8+0.5(19)	5.9+0.4(19)	2.6+0.3(19)	140+15(16)	0.16+0.01(19)	31.4+0.6(19)	29.7+0.2(9)
HYPO								
		Survey 3		August 27-29 1981				
All	19.3+0.4(42)	12.3+0.7(40)	5.9+0.5(42)	4.6+0.7(30)	76+ 4(38)	0.10+0.01(42)	27.5+0.5(14)	29.7+1.2(14)
Surface	20.6+0.1(15)	14.5+0.9(15)	6.3+0.8(15)	4.3+1.0(11)	69+ 3(14)	0.07+0.004(15)	28.1+0.9(5)	30.1+2.3(5)
EPI	20.4+0.1(32)	13.1+0.7(31)	5.8+0.5(32)	5.0+0.9(24)	69+ 2(30)	0.07+0.00(32)	28.0+0.6(10)	30.1+1.7(10)
META	15.8+0.8(10)	9.3+1.6(9)	6.4+1.6(10)	3.3+0.5(6)	105+13(8)	0.20+0.03(10)	26.4+0.2(4)	28.7+0.4(4)
HYPO								
		Survey 4		October 2-5 1981				
All	13.4+0.1(27)	19.1+0.6(26)	5.8+0.3(27)	7.2+3.8(26)	281+68(25)	0.15+0.00(26)	29.0+1.1(27)	30.2+0.3(8)
Surface	13.5+0.1(11)	18.7+1.0(11)	5.3+0.3(11)	1.9+0.4(11)	255+104(11)	0.15+0.00(11)	26.9+0.6(11)	29.7+0.1(3)
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

Oswego Harbor Nearshore Study
Lake Area
Oswego Stations (12A,13A,17,19,29)

Table 14 Con't

Depths	Chloro-phyll-a (ug/l)	TKN (mg N/l)	NH_3 Total (ug N/l)	Conductivity umohs/cm at 25°C	Alkalinity Total (mg $CaCO_3$/l)	pH (SU)	Turbidity NTU	Secchi Disk (m)
		Survey 1			April 27-28 1981			
All	5.6+0.3(11)	No Data	31.7+12.6(18)	325+1(20)	95.4+0.8(20)	8.21+0.04(20)	2.4+0.3(20)	2.2+0.4(10)
Surface	5.3+0.2(10)		36.3+23.8(10)	325+1(10)	96.3+0.3(10)	8.24+0.02(10)	2.6+0.4(10)	
0-20M	Same as All							
20M-Bottom								
		Survey 2			July 30-August 1 1981			
All	6.9+0.9(12)	0.38+0.02(23)	14.1+ 2.1(44)	328+2(45)	90.4+0.3(45)	8.39+0.02(45)	1.8+0.1(45)	2.7+0.2(15)
Surface	6.9+0.9(12)	0.38+0.03(13)	12.0+ 4.0(16)	323+3(16)	89.6+0.3(16)	8.51+0.03(16)	2.0+0.1(16)	
EPI	6.9+0.9(12)	0.38+0.03(17)	14.6+ 3.5(26)	322+2(26)	89.8+0.3(26)	8.49+0.02(26)	1.9+0.1(26)	
META		0.36+0.02(6)	13.4+ 1.4(18)	337+4(19)	91.1+0.5(19)	8.25+0.02(19)	1.7+0.0(19)	
HYPO								
		Survey 3			August 27-29 1981			
All	6.8+0.6(15)	0.40+0.04(9)	11.6+ 1.3(14)	323+3(42)	88.2+0.3(42)	8.42+0.03(42)	1.2+0.1(42)	3.4+0.1(15)
Surface	6.7+0.6(14)	0.40+0.04(9)	9.8+ 1.4(5)	330+6(15)	87.5+0.2(15)	8.53+0.03(15)	1.3+0.1(15)	
EPI	6.8+0.6(15)	0.40+0.04(9)	10.0+ 0.8(12)	325+3(32)	87.5+0.1(32)	8.52+0.02(32)	1.2+0.1(32)	
META			20.8+ 4.2(2)	318+1(10)	90.5+0.5(10)	8.09+0.03(10)	1.1+0.1(10)	
HYPO								
		Survey 4			October 2-5 1981			
All	6.1+0.5(10)	0.41+0.02(19)	12.4+ 1.3(27)	329+4(27)	90.6+0.2(27)	8.26+0.02(27)	1.7+0.3(27)	3.7+0.2(11)
Surface	6.1+0.5(10)	0.39+0.02(11)	12.4+ 2.0(11)	321+2(11)	90.4+0.2(11)	8.26+0.02(11)	2.0+0.8(11)	
EPI	Same as All							
META								
HYPO								

Results are reported as mean ± Standard Error (Number of Samples). "Depths" refers to water layers sampled; "All" includes all samples from the area; "Surface" includes 1 meter depths; "0-20M" includes upper 20 meters; "20M-Bottom" includes all depths below 20 meters; "EPI" includes the epilimnion; "META" includes the metalimnion; "HYPO" includes the hypolimnion.

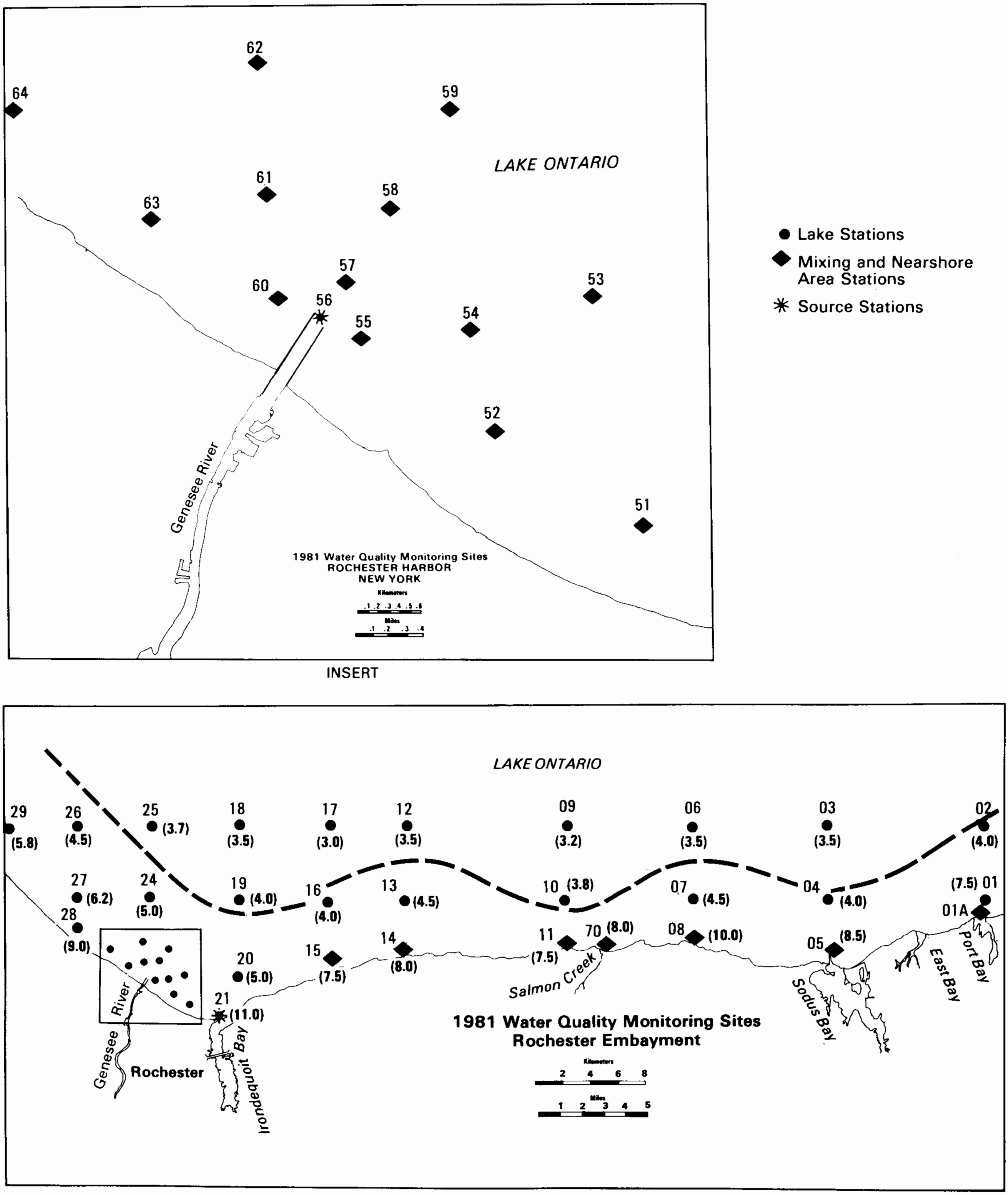

Figure 6. Water temperatures in the Rochester Embayment area, April 29–May 4, 1981. The dashed line corresponds to the location of the thermal bar (4 °C).

TURBIDITY AND SECCHI DISC DISTRIBUTION

Secchi Disc measurements are made to readily characterize the clarity of the water. Water transparency as measured by the Secchi Disc technique usually follows an inverse relationship to the annual cycle of chlorophyll concentrations (Ladewski and Stoermer 1973). The inverse relationship between Secchi Disc depth and chlorophyll-a concentrations (Carlson 1977, Chapra and Dobson 1981) has been developed by using the Beer-Lambert law for light extinction on water and the Secchi Disc depth corresponding to the level at which 90% of the surface light intensity has been dissipated by suspended particulate matter. One influence that interferes with this relationship is the resuspension of bottom sediments. Thus in the nearshore and mixing zones, Secchi Disc measurements can not be used for trophic status evaluation.

Turbidity in water is caused by the presence of suspended matter, such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Thus increased turbidity measurements should be correlated with decreased Secchi Disc measurements.

Niagara River Plume

The Secchi Disc readings averaged 2.4 m, 2.6 m, and 4.2 m in the river, mixing area, and lake area respectively for the four surveys. Turbidity readings ranged from 1.4 to 7.9 NTU, 1.4 to 4.6 NTU, and 1.4 to 3.8 NTU in the river, mixing area and lake area respectively for the four surveys. The higher levels were found in the first and fourth surveys.

Rochester Embayment

The Secchi Disc readings averaged 1.0 m, 2.8 m, and 4.2 m in the source, mixing and nearshore area and lake area respectively. Turbidity readings ranged from 3.8 to 16.9 NTU, 1.8 to 2.5 NTU, 1.1 to 2.6 NTU in the source area, nearshore and mixing area, and the lake area respectively for the four surveys. The higher levels primarily occurred in the first survey.

Oswego Harbor

The Secchi Disc reading averaged 1.0 m, 1.6 m, 2.5 m, and 3.0 m, in the Oswego River, inner harbor, outer harbor, and lake area respectively. Turbidity readings ranged from 4.2 to 5.4 NTU, 2.6 to 10.9 NTUS, 1.5 to 3.0 NTU, and 1.2 to 2.4 NTU in the river, inner harbor, outer harbor, and lake area respectively. The higher levels primarily occurred in the first survey.

pH DISTRIBUTIONS

pH is measured to characterize the physical environment in which the biota were found. In general, the pH vertical distribution is determined by biological utilization and liberation of CO_2. "In lakes where the bicarbonate alkalinity is high and the trophogenic zone is productive, the consequent high production of CO_2 in the hypolimnion causes a relatively small lowering of the pH of the well-buffered water" (Hutchinson 1957). A part of the production of CO_2 in the hypolimnion results from the oxidation of settled phytoplankton particulate matter from the epilimnion. A small part of the decrease of pH that is found in the hypolimnion may also be caused by release of silicic acid from diatom frustule dissolution (Marmorino et al. 1980). Seasonal cycles in pH reflect the photosynthesis and respiration of the plankton, which in turn influence the amount of CO_2 in the water (Wetzel 1975).

Niagara River Plume

The pH of the Niagara River varied within a narrow range from the first surveys levels of 8.16 ± 0.11 SU to the second survey levels of 8.54 ± 0.02 SU. Thereafter, pH values decreased. These levels were similar to those found in the Eastern Basin of Lake Erie (GLNPO-unpublished data). The fluctuations of pH in the river were similar to that of Lake Erie with August levels increasing 0.5 pH units above spring conditions, and fall levels decreasing about 0.25 pH units from its highest value (Table 5).

The pH in the mixing area varied in similar manner to that of the river. The first survey levels were 8.09±0.01 SU, and they increased to 8.54±0.01 SU by the second survey. Thereafter, levels decreased to 8.26±0.02 SU (Table 6). These changes in pH reflect only a small fraction of change in the relative proportion of inorganic carbon species in solution.

The pH in the surface waters and epilimnion of the lake area had a similar seasonal cycle as described for the river. The hypolimnetic water showed a decline in pH over the first three surveys from 8.11±0.01 to 7.90±0.02 SU (Table 7).

Rochester Embayment

The pH of the source area varied within a narrow range from 8.21±0.10 (first survey) to 8.40±0.04 SU (second survey), and declined thereafter to 8.14 SU (fourth survey, Table 8).

The pH of the mixing and nearshore areas was essentially constant, varying from 8.33 to 8.44 SU in the surface waters (Table 9). The pH of the hypolimnetic waters decreased from 8.32 to 7.76 SU between the first and second surveys. Thereafter the mixing and nearshore areas were homogeneous (Table 9). The lake area near Rochester had the same seasonal and vertical pH pattens as the Niagara River Plume lake area.

Oswego Harbor

The pH of the Oswego River varied within a narrow range between 8.05 and 8.31 SU. The seasonal progress as described for the Niagara River was not evident in the Oswego River (Table 11).

The pH of the inner harbor varied within a narrow range of 8.12 to 8.28 SU (Table 12). Outside the inner harbor, pH varied from 8.17 to 8.47 and 8.21 to 8.53 SU for the outer harbor mixing area and the lake area respectively (Tables 13-14).

CHLORIDE, SULFATE AND CONDUCTIVITY DISTRIBUTIONS

These parameters are measured to determine the boundaries of different water masses. The distribution of the conservative tracers, chloride and sulfate, did not show seasonal variations at lake sites. These variables should be unaffected by either temperature or the biota (Hutchinson 1957, Wetzel 1975).

The areal distributions for conductivity, sulfate, and chloride were considered a result of two factors: (1) input of high or low conductivity water from the major streams or runoff effects from the tributaries, and (2) mixing of these waters with Lake Ontario water in the nearshore zone.

Niagara River Plume

The lower conductivity of the Niagara River can be used as a tracer for that water mass. The Niagara River water dominated the segment east of the river mouth in all the surveys of the 1981 season. The mixing zone values of conductivity, chloride, and sulfate were more similar to those of the Niagara River mouth station than to those found in the station group which characterized the lake (Tables 5-7).

Although surface water samples from the mixing zone and from the lake stations were noticeably influenced by the Niagara River water, hypolimnetic waters reflected conductivity, chloride, and sulfate values similar to the spring values from the lake. This suggests that Niagara River water moved eastward but was confined to the epilimnetic layer. Niagara River water has been previously observed to move eastward and counterclockwise in Lake Ontario (USDI & NYSDH 1968, Robertson and Scavia 1984). LANDSAT photography (Mace 1983) also showed that the Niagara River waters mixed with lake surface waters primarily east of the Niagara River mouth.

The observed seasonal minimum in conductivity occurred during the second survey in the epilimnion distributions in the lake area. It was probably due to the reduction in carbonate ions from calcium carbonate precipitation. The precipitation of calcium carbonate crystals in the surface waters can be seen in the satelite photograph imagery of Lake Ontario in August 18, 1981 (Mace 1983) and has been observed by others (Robertson and Scavia 1984). This phenomenon has been observed also in Lakes Michigan (Rockwell et al. 1980) and Huron (Moll et al. 1984).

Rochester Embayment

The two principal sources of water to the Rochester Embayment are the Genesee River and the littoral drift of waters from the Niagara River. Of these two sources, the Niagara River is predominant since its flow is about 100 times greater than the Genesee River flow (USGS 1983). Although the Genesee River enters the Embayment directly and contains higher conductivity than the surrounding lake waters, its influence on the mixing zone was not appreciable in any survey (Table 5). Cluster analysis grouped the river mouth station (ROCH 56) and the Irondeqoit mouth station (ROCH 21) together. LANDSAT photography for August 18, 1981, also showed the limited areal extent of the Genesee River influence (Mace 1983).

During the first survey and the fourth survey the concentration patterns of the conservative substances were almost isochemical at the lake stations. Vertical concentration differences between the epilimnion and the hypolimnion were less in the Rochester area than in the Niagara River area. This reflected the lessening influence of the Niagara River on the lake surface water as the river water mixed with lake water and drifted eastward.

Oswego Harbor

The Oswego River had approximately 0.1 of the flow of the Genesee River (USGS 1983) and was directed within a harbor breakwall. The observed patterns of conductivity, chloride, and sulfate concentrations were reflective of the Oswego River water movements (Tables 7-10). The influence of the Oswego River on the harbor area was primarily eastward from the inner harbor area. This pattern was also observed by Bell (1978). River water containing higher conductivity appeared to sink into the hypolimnion and mix with lake water to the north and east of the inner harbor. Cluster analysis grouped the Oswego stations into four areas that reflected the influence of the river on those areas.

Oswego River water contained chloride and sulfate at concentrations up to 10 times that of the water at the nearshore stations (Table 11). These levels were also an order of magnitude greater than those measured at the mouth of the Niagara and Genesee Rivers.

ALKALINITY DISTRIBUTIONS

Alkalinity is measured to determine the physical environment in which the biota are found. The term alkalinity is used to express the total quantity of base in equilibrium with carbonate or bicarbonate that can be determined by titration with a strong acid (Hutchinson 1957). Alkalinity has often been considered to exert a considerable influence on algae (Hynes 1970), determining in part the genera and species. Since it is a measure of the buffering capacity, decreases in alkalinity in a well buffered system could imply a significantly increased loading of acid.

Niagara River Plume

The Niagara River alkalinity ranged between 84 and 96 mg/l during the four surveys. For comparison, alkalinity levels found in Eastern Lake Erie are in the range 95-100 mg/l (GLNPO, unpublished data).

The alkalinity levels of the remainder of the study area were fairly uniform with most values in the low to mid-nineties (92 to 94 mg/l).

Rochester Embayment

In Rochester source areas, alkalinity ranged between 88 and 118 mg/l during the four surveys.

The alkalinity levels of the remainder of the embayment were fairly uniform with values in the high eighties (89 mg/l) and low nineties (93 mg/l).

Oswego Harbor

The Oswego River alkalinity ranged between 91 and 103 mg/l during the four surveys. The inner harbor alkalinity level was similar and ranged from 98 to 102 mg/l.

The outer harbor alkalinity and the lake area alkalinity were fairly uniform and ranged from the high eighties (87 mg/l) to the high nineties (97.9 mg/l).

CALCIUM, MAGNESIUM AND SODIUM DISTRIBUTIONS

Concentrations of the alkali and alkaline earth compounds depend on the geology of the basins drained. Limited areal surveillance of these compounds was done to characterize their concentrations during the August survey.

Calcium found in water supplies leaches from deposites of limestone, dolomite, gypsum and gypsiferous shale. Calcium, sodium, and magnesium are common elements in the earth's crust, and they rank fifth, sixth, and eighth in the order of abundance respectively. These elements appear to be biologically conservative, by which it is meant that biological processes do not alter their concentrations in water very much over the year.

Changes in calcium concentration have been noted due to precipitation of calcium carbonate from the epilimnion and resolubilization in the hypolimnion during the stratified period (Mace 1983, Robertson and Scavia 1984).

Niagara River Plume

At the Niagara River site, calcium, magnesium, and sodium were measured in August at 37.8, 8.06, and 9.06 mg/l respectively.

The lower concentrations of calcium and magnesium in the mixing area were statistically different from those at the river site. Calcium, magnesium and sodium mean concentrations $\pm$ standard error, and low-high values were 36.8$\pm$0.3, (35.7-37.9) mg Ca/l, 7.88$\pm$0.05 (7.69-8.07) mg Mg/l, and 9.09$\pm$0.24 (8.36-10.8) mg Na/l, respectively.

In the lake area, the lower concentrations of calcium and magnesium were also statistically different from those at the river site. Lake area mean levels for these elements were lower than the mixing area, but the differences were not statistically significant at the 95% confidence level. Calcium, magnesium, and sodium mean concentrations $\pm$ standard error, and low-high values were 36.1$\pm$0.2 (35.1-36.6) mg Ca/l, 7.72$\pm$0.06 (7.52-7.86) mg Mg/l, and 9.67$\pm$0.35 (8.73-11.2) mg Na/l.

Rochester Embayment

No source stations were monitored for calcium, magnesium, and sodium in the August survey.

The mixing area and nearshore zone contained data from 12 locations. Calcium, magnesium and sodium mean concentrations $\pm$ standard error, and low-high values were 38.0$\pm$0.9 (35.3-46.8) mg Ca/l, 8.02$\pm$0.15 (7.57-9.38) mg Mg/l, and 13.71$\pm$1.41 (10.7-27.9) mg Na/l respectively. Station 57, immediately adjacent to the Genesee River mouth, had the highest observed values. These values were all statistically different from the rest of the mixing zone.

The open lake contained data from 13 locations. The mean concentrations were lower for all parameters, but not statistically different from those of the mixing zone. Calcium, magnesium, and sodium mean concentrations $\pm$ standard error, and low-high values were 37.3$\pm$0.4 (35.7-40.6) mg Ca/l, 7.88$\pm$0.12 (7.57-9.25) mg Mg/l, and 11.71$\pm$0.18 (10.7-13.0) mg Na/l respectively.

Oswego Harbor

The Oswego River contained 68.0 mg Ca/l, 9.48 mg Mg/l and 60.8 mg Na/l during the August survey. In the Inner Harbor area, water samples from stations 4, 28 and 5 contained 45.4, 51.0 and 13.1 mg Ca/l respectively; 8.25, 8.55 and 1.95 mg Mg/l respectively; and 22.2, 31.2, and 10.5 mg Na/l respectively. The data from station 5 were anomolous, not only in comparison to other Inner Harbor data, but also in comparison to those from all other Oswego Harbor stations. The cause for these atypical results is not known. The concentrations of Ca and Mg in the Inner Harbor area were significantly different from those of the Oswego River. The calcium, magnesium, and sodium mean concentrations $\pm$ standard error and low-high values were 43.8$\pm$2.0 (38.6-48.0) mg Ca/l, 7.98$\pm$0.03 (7.92-8.05) mg Mg/l, and 22.60$\pm$2.73 (15.1-27.9) mg Na/l respectively.

The lake area contained the lowest observed mean concentrations in the Oswego Harbor area. The differences in concentrations between the lake and outer harbor study area were all statistically significant. Calcium, magnesium, and sodium mean concentrations $\pm$ standard error and low-high values were 35.1$\pm$0.6 (33.6-48.0) mg Ca/l, 7.52$\pm$0.09 (7.36-7.86) mg Mg/l and 11.88$\pm$0.39 (10.6-12.9) mg Na/l respectively.

TRACE METALS DISTRIBUTIONS

Trace metals concentrations can vary considerably in a short time period due to sediment resuspension, storm runoff, and turbulent mixing in shallow nearshore areas. To minimize these storm-related effects of particulates on total trace metals concentrations, epilimnetic water samples from the August survey were selected for analysis. The late summer water masses were stratified and stormy episodes were less frequent during this season. In addition, atmospheric sources contribute to the trace metal contamination of the lake from both dry loading (Sievering et al. 1984) and precipitation (Klappenbach 1985). To detect violations for pollutants with significant atmospheric contributions, the late summer period was chosen because the highest concentrations of metals would be expected in the epilimnion.

The results of the trace metal analyses were compared with the IJC specific objectives for total trace metals. In only a few samples was the concentration of a heavy metal greater than the objective. Additional discussion may be found in the section "Parameters Exceeding Criteria and Objectives" below. Complete results may be found in Appendix A, Microfiche of Data.

PHENOL DISTRIBUTIONS

Phenol and phenolic compounds are associated with taste and odor problems in drinking water and tainting problems in edible aquatic organisms. The 1978 Great Lakes Water Quality Agreement (IJC 1978) provided a 1 ug/l criterion. "Quality Criteria for Water 1976" (EPA 1976) states a criterion of 1 ug/l for domestic water supply and for protection against fish flesh tainting. McKee and Wolf (1963), as cited by EPA (1976), concluded that phenol in a concentration of 1 ug/l would not interfere with domestic water supplies, and 200 ug/l would not interfere with fish and aquatic life.

Niagara River Plume

No analysis for phenol was done.

Rochester Embayment

Analysis for phenol was completed on a total of 21 samples collected at stations 5, 56, and 70. Phenolic compounds were detected at each station. The phenol concentration in six samples were below the level of detection of 4 ug/l, and the maximum concentration was 22 ug/l.

Oswego Harbor

Analysis for phenol was completed on two samples collected at station 3. No phenolic compounds were detected.

DISSOLVED OXYGEN DISTRIBUTIONS

Oxygen is moderately soluble in water, but the solubility decreases in a non-linear manner with increasing temperature. If the dissolved oxygen concentrations at depth are not very far from saturation, equilibrium at prevailing temperatures and altitudinal pressure is established relatively quickly, usually in a matter of a few days for shallow lakes. Equilibrium might not be achieved before thermal-stratification is established in very deep lakes (Wetzel 1975). The intensity of oxidative processes that occur in the hypolimnion of stratified lakes is determined in part by the amount of organic matter settling out of the photic zone. As a result, the dissolved oxygen concentration in the hypolimnion becomes more reduced as the stratified season progresses. In the photic zone, where biotic effects may be expected, considerable deviation from saturation may occur. The presence of super-saturation is presumably attributable to photosynthesis. High organic production is correlated with increases in the range of observed surface oxygen concentrations (Hutchinson 1957).

The vertical distribution of dissolved oxygen concentrations has been used to identify the trophic status of a lake. A pattern of increasing dissolved oxygen concentration below the thermocline (orthograde pattern) is characteristic of an unproductive or oligotrophic lake. A pattern of decreasing dissolved oxygen concentration below the thermocline (clinograde pattern) is characteristic of a productive (eutrophic) lake (Wetzel 1975).

During surveys 1,2, and 4 dissolved oxygen was measured only at the B-2 sample depth. During survey 3 dissolved oxygen was measured at all sample depths. This survey occurred during late August when maximum oxygen depletion was anticipated due to the summer stratification. The results from each study area during each survey are presented in Table 15. Dissolved oxygen levels were not seriously depleted at any time during the survey. Except for one observation at 61% saturation, all values were above 72% saturation.

Niagara River Plume

In the lake study area, the dissolved oxygen concentrations generally increased with increasing depth, except for the bottom water sample. The observed decrease in D.O. near the sediments may have been due to bacterial respiration associated with the decomposition of sedimented organic matter. In the mixing study area, D.O. concentrations generally decreased with increasing depth. In the source area, D.O. increased with depth.

Rochester Embayment

In the lake area, the pattern of D.O. concentrations with depth was similar to that in the Niagara Plume, lake study area. A mixture of decreasing and increasing D.O. concentrations were observed with increasing depth at the mixing and nearshore stations. At approximately 2/3 of the stations, decreasing D.O. concentrations were observed with increasing depth. At the source area stations, the vertical pattern of D.O. concentrations was variable.

Table 15. Percent Saturation of Dissolved Oxygen: Range and Sample Station Where Lowest Observation Was Found

Sub Area	Survey 1	Survey 2	Survey 3	Survey 4
Niagara River Plume				
Lake Area	89-108 Station 7	83-95 Station 9	74-109 Station 15	80-94 Station 9
Mixing Area	83-111 Station 17	92-117 Station 5	87-126 Station 11	94-102 Station 11
Source	101-106 Station 1	106-106 Station 1	99-112 Station 1	101-102 Station 1
Rochester Embayment				
Lake Area	98-111 Station 9	61-105 Station 29	78-124 Station 20	80-104 Station 3
Mixing and Nearshore Area	110-118 Station 8&14	79-114 Station 60	78-124 Station 14	91-103 Station 61
Sources	100-104 Station 56	91-114 Station 56	91-108 Station 56	87-99 Station 56
Oswego Harbor				
Lake Area	100-117 Station 13A	93-113 Station 19	77-111 Station 19	75-98 Station 17
Outer Harbor Area	90-103 Station 22A	96-118 Station 22A	73-105 Station 7	92-98 Station 37
Inner Harbor Area	91-102 Station 37	96-132 Station 5	93-105 Station 7	92-98 Station 37
Source	100-106 Station 3	89-97 Station 3	80-95 Station 3	91-94 Station 3

Oswego Harbor

The D.O. concentrations at all stations except 13A decreased with increasing depth.

SOLUBLE REACTIVE PHOSPHORUS (SRP) DISTRIBUTIONS

Inorganic orthophosphate comprises most of the soluble reactive phosphorus that is measured by routine laboratory techniques, and orthophosphate has been considered the limiting nutrient for algal growth in most of the Great Lakes (Beeton 1969). For those waters in which phosphorus is the limiting nutrient, increases in orthophosphate loading to the water can result in greatly increased growths of algae. Inputs of soluble nutrients to the nearshore areas of lakes often cause increased biological activity at these sites in spring and summer (Shiomi and Chawla 1970).

The relationship between SRP concentrations in water and phytoplankton production, however, may be complex. Dobson et al. (1974) suggest that phosphorus is the major limiting factor for summer phytoplankton production in Lake Ontario because high algal demand for SRP in the photic zone results in very low phosphorus concentrations. Many algal species are able to store phosphorus when it is present in non-limiting concentrations, thereby creating the appearance of phosphorus-limited conditions (Schelske 1979). Also, algal species vary in their requirements for minimum and maximum phosphorus concentrations (Wetzel 1975).

During stratified conditions in open lake waters, the photosynthetic activity of algae in the epilimnion typically causes depletion of SRP, while respiratory and catabolic activities of bacteria and other biota in the hypolimnion cause the release of SRP.

Niagara River Plume Area

SRP levels in the river were nearly constant throughout the survey periods, ranging from 2.3±0.6 ug P/l in April during ice out conditions to 3.3±0.5 ug P/l in August (Table 5). SRP levels in the mixing area were also uniform throughout the survey periods, ranging from 1.7±0.1 ug P/l to 3.4±0.3 ug P/l (Table 6). SRP levels in the surface waters of the lake area ranged from 3.1±0.3 ug P/l in the spring to 1.7±0.3 ug P/l in October (Table 7). These levels were an order of magnitude above SRP levels found in Lakes Huron and Michigan (Lesht and Rockwell 1985). Hypolimnetic SRP values, 4.7±2.1 ug P/l in August to 6.6±0.7 ug P/l in October, were two to four times higher than the epilimnion values.

Rochester Embayment Area

SRP levels in the source areas (Genesee River and Irondequoit Bay) varied from 4.8 to 19.8 ug P/l during the survey periods (Table 8). The mixing and nearshore area SRP levels were fairly constant and ranged between 1.4 and 3.9 ug P/l with the higher levels occurring during the same survey in which the high levels were found in the source area. SRP levels in the surface waters of the lake area ranged from 1.5 to 3.8 ug P/l and reflected a seasonal depletion during the July and August survey (Table 10). Elevated SRP values were found in the hypolimnion with values two to four times higher than the epilimnion levels.

SRP levels had a distinct areal pattern in the Embayment during the first survey. Lower levels (<3.5 ug P/l) were found inside the thermal bar and higher levels (>5 ug P/l) were found outside the thermal bar (Figure 7). The formation of the thermal bar typically promotes higher biological production, and therefore reduced SRP concentrations, in the nearshore area (Rogers and Sato 1970).

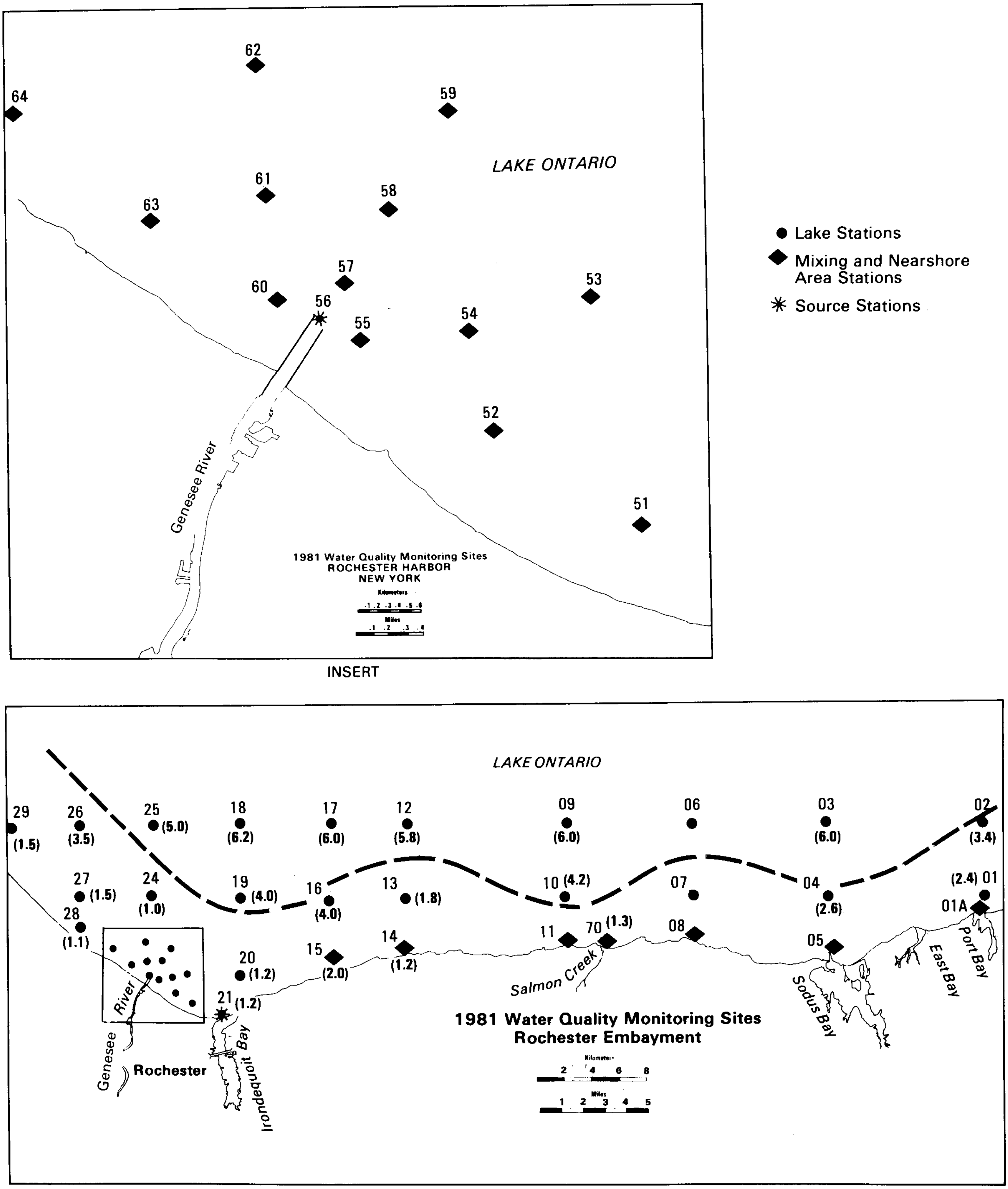

Figure 7. Concentrations of soluble reactive phosphorus (ug/liter) in the Rochester Embayment area, April 29-May 4, 1981. The dashed line corresponds to the location of the thermal bar (4.°C).

Oswego Harbor

SRP levels in the Oswego River increased by a factor of four during the survey periods, ranging from 5.3 to 21.6 ug P/l (Table 11). SRP levels within the inner harbor showed almost the same increase and ranged from 4.6 to 16.6 ug P/l (Table 12). SRP levels outside the inner harbor in the plume area of the Oswego River were fairly stable (3.2 to 2.5 ug P/l) in surveys 1 through 3 respectively (Table 13). SRP levels in the fourth survey increased to 5.8 ± 1.2 ug P/l and reflected the highest measured input levels from the the Oswego River. SRP levels in the surface waters of the lake area ranged from 1.2 to 4.3 ug P/l. Vertical SRP differences were not found in this study area because insufficient water depth prevented the formation of a permanent hypolimnetic water layer.

TOTAL PHOSPHORUS AND TOTAL DISSOLVED PHOSPHORUS DISTRIBUTIONS

Total phosphorus (TP) is monitored in limnology programs in response to anthropogenic loadings of phosphorus to the lakes. Total dissolved phosphorus (TDP) is measured to permit determination of the particulate fraction of phosphorus and to estimate the bioavailable fraction of total phosphorus. The seasonal cycle and areal distributions of total phosphorus are closely tied to phytoplankton biomass and productivity (Paerl et al. 1975). Usually, nutrient uptake by phytoplankton occurs primarily in the epilimnion, followed by settling of the particulate matter into the hypolimnion.

Niagara River Plume

During surveys 1 and 4, higher levels of total phosphorus were observed in the river (19.5±2.1 and 31.6±6.0 ug P/l respectively) than during surveys 2 and 3 (11.3±0.3 and 9.0±0.9 ug P/l respectively). Survey 1 occurred during ice out conditions, and survey 4 occurred during a stormy period. Areal surface patterns were irregular, but TP levels generally decreased away from the Niagara River mouth during surveys 1 and 4. The opposite pattern was observed during surveys 2 and 3 (Tables 5-7). TP levels in the mixing area tended to be more like those found in the river during surveys 1 and 4 and more like the lake area during surveys 2 and 3.

Total dissolved phosphorus levels in the Niagara River Plume area were similar during the four surveys and at most depths. Concentrations varied between 4 and 7 ug P/l. Only one observation was outside this range (Survey 4, hypoliminon, 10.6±0.8 ug P/l).

Rochester Embayment

The source areas had TP levels two to three times the levels found in the lake, the mixing and nearshore areas (Table 8-10). Areal distribution patterns were irregular in the Embayment except during the first survey when the offshore stations outside the thermal bar were found to have TDP concentrations above 8 ug P/l and stations inside the thermal bar were found to have TDP concentrations below 8 ug P/l.

Total phosphorus concentrations in the lake area epilimnion were greater than 17.7±0.4 ug P/l during the stratified period (maximum 21.7±3.1 ug P/l). The mixing and nearshore TP concentrations were similar to those of the lake area except during survey 4 when the nearshore TP was 10 ug P/l higher. Overall, the mixing and nearshore mean TP concentrations averaged about 21 ug P/l, and were 3 to 4 ug P/l higher than those of the lake areas.

Total dissolved phosphorus concentrations ranged between 5.6 and 10.3 ug P/l in the surface waters of the Embayment. Source water TDP concentrations were between 8.8 and 16.7 ug P/l.

Oswego Harbor

TP and TDP levels were highest in the Oswego Harbor area of the three nearshore areas surveyed. The Oswego River TP and TDP levels were the highest of the four study areas in the Oswego Harbor. They did not fluctuate as the spring and fall TP and TDP levels observed in the Niagara and Genesee Rivers (Table 11).

Inner harbor TP and TDP concentrations were statistically different from the outer harbor concentrations. Inner harbor TP levels were not lower than 47.1 ug P/l. Outer harbor TP concentrations were not higher than 35.5 ug P/l.

The lake area to the west of the harbor had TP levels between 12.3 and 19.1 ug P/l during the four surveys. The outer harbor study area showed total phosphorus levels elevated from 7 ug P/l to 16 ug P/l compared to the levels in the lake area (Tables 13-14).

AMMONIA - NITROGEN DISTRIBUTION

Ammonia is measured together with TKN to determine the particulate fraction of organic nitrogen. It can be used to track the impact of municipal waste discharges. The nutrient dynamics of ammonia tend to fall between those of orthophosphorus and nitrate (Fogg 1975). Although ammonia is not a limiting nutrient, it is a highly available form of nitrogen for algal uptake (Eppley et al. 1969). As a result, ammonia generally remains at a constant low level (less than 10 ug/l) when it originates from aquatic animal excretion (zooplankton and fish excretion). Discharge from municipal sewage treatment plants into the river system can result in concentrations greater than 100 ug N/l.

Niagara River Plume

Ammonia levels in the lake were fairly uniform by layer with all samples averaging between 5.4 and 8.7 ug N/l in the first, third, and fourth surveys. Ammonia levels increased between the first and second surveys to an average of 25.8 ug N/l for all samples (Table 7). These high levels decreased by the third survey when nitrite-nitrate nitrogen was also depleted. Ammonia levels around 3 ug N/l are typical of open lake ammonia levels in oligotrophic lakes (Lesht and Rockwell 1985).

Ammonia levels in the Niagara river ranged between 12.5 ug N/l and 34.0 ug N/l.

Rochester Embayment

Mean ammonia levels in the lake area were low during the first survey (4.8 ug N/l) and ranged between 11.0 and 24.0 ug N/l during the last three surveys. Ammonia levels in the source area ranged between 27.9 and 144 ug N/l. These concentrations imply a smaller loading to the Genesee River than to the Niagara River since its mean flow (2869 ft^3/Sec) is about 0.01 that of the Niagara River (239,000 ft^3/Sec).

Oswego Harbor

Average ammonia levels in the lake area were fairly constant after the first survey and ranged between 11.6 and 14.1 ug N/l for all samples. The first survey had higher mean ammonia levels. These levels were probably associated with the increasing water temperature inside the thermal bar.

The highest ammonia concentrations were found in the Oswego River. The concentrations ranged from 60 to 188 ug N/l. Since the Oswego River had a mean flow (245 ft^3/Sec) that was about 0.001 that of the Niagara River, the ammonia loading to the Oswego River was less than that to the Genesee and the Niagara Rivers.

NITRITE AND NITRATE NITROGEN DISTRIBUTIONS

Nitrite and nitrate nitrogen are soluble inorganic forms of nitrogen, and they are readily available to plants. They are the principal nitrogen source for algal growth. In unpolluted fresh water, most of the inorganic oxidized N occurs as nitrate. Nitrite concentrations are generally much lower. As an analytical convenience, therefore, the total concentration of N from the two forms is determined and reported. Seasonal and areal changes of nitrate-nitrogen concentrations are expected since summer phytoplankton growth reduces surface nitrogen concentrations, while concentrations in the hypolimnion increase from the accumulation of decaying material (Wetzel 1975). Nitrate depletion in the epilimnion may occur with increasing degrees of eutrophication (Schelske and Roth 1973).

Niagara River Plume

The areal pattern observed was for higher nitrite and nitrate concentrations to be found in the surface waters of the lake, and for lower concentrations to be found near the river and along the eastern shoreline. Spring surface levels in the lake area were the highest observed (0.32 mg N/l). Maximum seasonal depletion of nitrite and nitrate in the surface waters was 69% in the river and mixing areas, and 67% in the lake (Table 5-7). These comparisons are made with results from the first survey representing the "base-line" levels.

Rochester Embayment

Nitrite and nitrate concentrations fluctuated in the study area day-to-day and station-to-station as much as 0.05 mg N/l (typical levels varied from 0.2 to 0.3 mg N/l) such that areal patterns are difficult to characterize. During the thermal bar period, however, the mixing and nearshore areas had lower nitrite and nitrate concentrations than were found in the open waters. The highest level was observed during the fourth survey in the source area (0.45 mg N/l). The maximum level observed in the surface waters of the Embayment was 0.31 mg N/l in the spring survey. The maximum seasonal depletion observed in the surface waters was 62% in the source area, 68% in the mixing and nearshore area, and 81% in the lake area (Tables 8-11) when compared with the "baseline" levels represented by the first survey.

Oswego Harbor

A decrease in surface nitrite and nitrate concentrations was observed from the river to the lake area. At the Oswego River station the highest nitrite and nitrate level was 0.50 mg N/l. An increase in nitrite and nitrate concentrations of 0.39 mg N/l in the river was observed between the third and fourth surveys (Table 11). Maximum seasonal depletions were observed to be 70% (river), 77% (inner harbor), 74% (outer harbor) and 75% (lake area) when compared with the "base-line" levels represented by the first survey.

KJELDAHL NITROGEN - PARTICULATE NITROGEN DISTRIBUTIONS

Kjeldahl nitrogen (TKN) is the sum of organic nitrogen and ammonia. Primary production (algal photosynthesis) is the major process that converts dissolved nutrient pools into particulate pools (Wetzel 1975). The processes that affect particulates, such as settling, advection, grazing, metabolism, and dissolution, affect TKN. The vertical distribution of TKN is affected by these processes to various degrees. Early seasonal increases of TKN throughout the water column reflect the conversion of dissolved nutrients into particulate organic forms by phytoplankton. Concentrations of TKN will decrease throughout the water column when cellular metabolism breaks down organic N at a rate faster than it is being fixed. Bacterial metabolism of extra cellular products may be a major contributing factor (Hellebust 1974).

Niagara River Plume

Organic nitrogen represented at least 94% of the TKN in the river and at least 86% of the TKN in the mixing zone of the river during surveys 3 and 4 (Table 6 and 7).

The vertical distribution of organic nitrogen in the lake area indicated a higher percentage of particulate matter in the lower layer. Organic nitrogen in the epilimnion represented at least 65% of the TKN, and in the hypolimnion it was at least 86% of the TKN.

Rochester Embayment

No TKN data are available for the first survey. In the source area, organic nitrogen represented 75% of the TKN during survey 4 (Table 8) and greater than 92% in surveys 2 and 3. In the Embayment, organic nitrogen represented at least 93% of the TKN during the last three surveys (Table 9).

In the open lake, the hypolimnion organic nitrogen represented at least 97% of the TKN, while the epilimnion organic nitrogen represented at least 94% of the TKN (Table 10).

Oswego Harbor

In the Oswego River, organic nitrogen represented at least 86% of the TKN during the last three surveys (Table 11). In the inner harbor, organic nitrogen represented at least 76% of the TKN during the last survey and at least 94% of the TKN during surveys 2 and 3 (Table 12).

In the outer harbor, organic nitrogen represented at least 90% of the TKN during all surveys (Table 13). In the lake, organic nitrogen represented at least 94% of the TKN during all surveys (Table 14).

The largest TKN values observed in all Oswego areas occurred during the third survey when the lowest concentrations of soluble reactive phosphorus and NO_2+NO_3 were observed. This relationship would be expected as the dissolved nutrients were converted into particulate organic forms.

DISSOLVED REACTIVE SILICA DISTRIBUTIONS

Limnological programs monitor dissolved reactive silica (DRS) because it is a major nutrient for diatoms. Depletion of silica occurs with increasing eutrophication (Schelske and Stoermer 1971). An annual cycle of vertical profiles of dissolved reactive silica has been observed in Lake Ontario (Shiomi and Chawla 1970). Vertical distributions involve an increase in hypolimnetic DRS that is attributed to intense silica utilization by diatoms and silicoflagellates in the epilimnion, followed by their sinking into the hypolimnion (Schelske and Stoermer 1971). During the present study, the spring surface concentrations were much lower in Lake Ontario than those observed in Lake Michigan (Schelske and Stoermer 1971, Rockwell et al. 1980) and Lake Huron (Moll et al. 1985).

Niagara River Plume

DRS in the Niagara River ranged from 24 ug Si/l during the first survey to 132 ug Si/l during the fourth survey, thereby reflecting the silica-depleted waters of Lake Erie (Table 5). The nearshore mixing zone also had relatively low levels of silica during the first survey, thereby demonstrating the influence of the Niagara River Plume (Table 6). Seasonal depletion of silica could not be seen, except in the lake area where the influence of the Niagara River plume was more limited. In comparing the first survey with the third survey, the maximum depletion observed was 53%. The DRS in the hypolimnion increased from 155 ug Si/l during the first survey to 395 ug Si/l by the fourth survey. This was the highest concentration observed during the stratified period in this study (Table 7).

Rochester Embayment

The concentration of DRS in the surface waters of the source area was 648 ug Si/l during the first survey, while the DRS level in the mixing and near-shore zone was 83 ug Si/l (Tables 8-9). The DRS concentration in the lake area during this survey was 121 ug Si/l (Table 10).

The vertical distribution of DRS in the Embayment was most pronounced in the lake area where a maximum depletion of 64% was observed in the epilimnion, when results from the second survey were compared with "base-line" conditions represented by the first survey.

Oswego Harbor

The mean DRS concentrations in the Oswego River were similar to the mean DRS concentrations in the Genesee River (Table 11). Generally, the DRS concentration decreased with increasing distance from the river mouth.

Isothermal conditions occurred in the lake area of the Oswego Harbor during survey 4. The mixing of the hypolimnion waters with the epilimnion layer resulted in the highest lake surface DRS concentrations (255 ± 104 ug Si/l) found during the study (Table 14).

CHLOROPHYLL-A AND PHEOPHYTIN DISTRIBUTIONS

The distribution of chlorophyll-a and pheophytin is closely tied to phytoplankton concentration. Because of the relationships between nutrients and chlorophyll-a, chlorophyll distributions have been thoroughly analyzed on both temporal and spatial scales. A typical annual cycle of surface chlorophyll-a values has been observed throughout the Great Lakes: a spring bloom of phytoplankton follows the annual minimum values during the winter, and relatively low surface chlorophyll-a levels during midsummer are followed by a small fall algal bloom (Glooschenko and Moore 1973, Fee 1976, Munawar and Burns 1976, Vollenweider et al. 1974). The areal distribution of chlorophyll is often used as an indication of high algal growth areas due to nutrient loading (Holland and Beeton 1972, Robertson et al. 1971).

Because pheophytin is a degradation product of chlorophyll, the ratio of pheophytin to the sum of chlorophyll-a plus pheophytin pigments may indicate the general physiological health of the phytoplankton. Lower percentages indicate active healthy populations while higher percentages imply declining or stressed populations.

Niagara River Plume

The Niagara River had lower levels of chlorophyll-a than the rest of the Niagara River Plume area ranging from 0.23 to 4 ug/l with a average value of 1.8 ug/l over the four surveys (Table 5). The mixing zone had levels of chlorophyll-a ranging between 2.0 and 3.8 ug/l with an average value of 3.3 ug/l over the four surveys (Table 6). The lake area had levels of chlorophyll-a ranging between 1.5 and 3.7 ug/l with an average value of 2.7 ug/l over the four surveys (Table 7).

On an annual basis, the levels of chlorophyll-a in the Niagara River might be expected to be lower than Lake Ontario levels since Eastern Basin Lake Erie annual levels in 1980 were below 2.5 ug/l (Herdendorf 1983) and the attenuation of phytoplankton by waterfalls and within a fast flowing river has been observed on many rivers (Hynes 1970). However, the first survey showed that the Niagara River had higher levels of chlorophyll-a that dominated the nearshore zone.

The ratio of pheophytin to total pigments increased with each successive cruise at all study areas (Table 16). The Niagara River had both the lowest and highest ratios observed: 0.130 during survey 1 and 0.909 during survey 4. Except during survey 1, the Niagara River exhibited higher ratios than the mixing or lake study areas. The ratios observed during survey 4 in the mixing and lake areas (0.499 and 0.462 respectively) were consistent with the elevated ratio in the Niagara River, and they were greater than the ratios observed at any other Lake Ontario study area.

Rochester Embayment

The source area had higher levels of chlorophyll-a than the rest of the Embayment areas. These values ranged from 5.1 to 12.7 ug/l with a mean level of 7.4 ug/l (Table 8). The mixing and nearshore area had levels of chlorophyll-a ranging between 4.7 and 5.2 ug/l with a mean level of 5.0 ug/l (Table 9). The lake area had levels of chlorophyll-a ranging between 2.9 and 5.4 ug/l with a mean level of 4 ug/l (Table 10). The higher level of chlorophyll-a in the source area was consistant with the higher levels of nutrients there compared to the rest of the Embayment.

The ratio of pheophytin to total pigments at all study areas in the Rochester Embayment was lowest during survey 2 (0.072 - 0.129) and highest during survey

Table 16: Average ratio of (pheophytin-a)/(chlorophyll-a + pheophytin-a) in surface water from Lake Ontario, 1981

Niagara River Plume

Survey	Source Area	Mixing Area	Lake Area
1	0.130	0.160	0.169
2	0.487	0.290	0.191
3	0.475	0.318	0.327
4	0.909	0.499	0.462

Rochester Embayment

Survey	Source Area	Mixing Area	Lake Area
1	0.215	0.145	0.166
2	0.129	0.072	0.105
3	0.270	0.304	0.339
4	0.234	0.235	0.207

Oswego Harbor

Survey	Source Area	Inner Harbor Area	Outer Harbor Area	Lake Area
1	0.256	0.325	0.263	0.142
2	0.163	0.164	0.157	0.161
3	0.453	0.374	0.310	0.376
4	0.217	0.235	0.187	0.158

3 (0.270 - 0.339, Table 16). Except during survey 3, the pheophytin ratio in the source area was equal to or greater than that from the mixing or lake areas. Within each survey, however, the difference between the ratios from the individual study areas was never greater than 0.069. Although the chlorophyll-a concentrations were also highest during survey 3 at all stations, the greater proportion of pheophytin in the algal pigments implied that the phytoplankton were stressed, perhaps by nutrient limitations. Lower concentrations of chlorophyll-a were observed during survey 4, but the reduced proportion of pheophytin indicated the presence of non-scenescent algal populations.

Oswego Harbor

The Oswego River had higher levels of chlorophyll-a than the rest of the harbor area. These values ranged from 9.5 to 21.2 ug/l with a mean level of 13.2 ug/l (Table 11). The inner harbor mixing area had chlorophyll-a values ranging from 9.0 to 13.1 ug/l with a mean level of 11.2 ug/l (Table 12). The outer harbor mixing area had chlorophyll-a values ranging from 7.0 to 12.4 ug/l with a mean level of 9.0 ug/l (Table 13). The lake area had chlorophyll-a values ranging from 5.6 to 6.9 ug/l with a mean level of 6.4 ug/l (Table 14). The river area had higher levels of nutrients than the rest of the harbor, consistent with a higher biomass as measured by chlorophyll-a.

The ratio of pheophytin to total pigments in the Oswego Harbor area was generally lowest during survey 2 (0.157-0.164) and greatest during survey 3 (0.310-0.453) at all study areas (Table 16). During survey 1, the pheophytin ratio was lowest at the lake study area, and during survey 4, the ratios at the lake and outer harbor areas were lower than those at the river and inner harbor areas. These ratios suggest that the phytoplankton were of similar physiological condition at all study areas during the summer months, but that the phytoplankton within the influence of the Oswego River were somewhat stressed during surveys 1 and 4 relative to the lake study area.

PARAMETERS EXCEEDING CRITERIA AND OBJECTIVES

Three sets of criteria were used to evaluate the chemical parameters of water quality.

They were:

1) Specific objectives from Annex 1 of the 1978 Great Lakes Water Quality Agreement between Canada and the United States of America, which are designed to protect raw (untreated) waters for public water supplies and to protect aquatic life living in these waters.

2) Guidance criteria for "A" waters of Human Effects New York Department of Environmental Conservation (NYDEC 1984) and,

3) Aquatic Criteria - New York Department of Environmental Conservation (NYDEC 1984).

The parameters which exceeded each of these guidelines are listed in Tables 17-19.

Table 17. Parameters Exceeding Annex 1 Specific Objectives of the 1978 Great Lakes Water Quality Agreement

Parameter	Location	Percentage of samples at site exceeding guidelines	Number of samples per station site	Proportion of stations within study area exceeding guidelines
Cadmium	Rochester 03,04,10,11 24,29,51,57 60	100%	1	9/43
pH	Niagara 01	2%	41	1/22
Cadmium	Oswego 09	100%	1	1/15

Table 18. Parameters Exceeding the NYDEC Effects Guidance Criteria

Parameter	Location	Percentage of samples at site exceeding guidelines	Number of samples per station site	Proportion of stations within study area exceeding guidelines
Aluminum	Rochester 57	100%	1	1/43
Aluminum	Oswego 03	100%	1	1/15

Table 19. Parameters Exceeding the NYDEC Aquatic Effects Guidance Criteria

Parameter	Location	Percentage of samples at site exceeding guidelines	Number of sample per station site	Proportion of stations within study area exceeding guidelines
Silver	Rochester 57	100	1	1/43

These few exceedances appear to be minor. However, the trace metals were analyzed for only one run of the third survey.

OTHER RESULTS

Other data not specifically discussed in the text are available in Appendix A, Microfiche of Data. Air Temperature, Wind Speed, Wave Height and Wave Direction are given by location and survey. Limited data on TOC is also presented.

DISCUSSION

The dynamic nature of the turbulent nearshore zone and the interaction with major tributaries requires a dense station network and high frequency sampling over a large areal extent to produce interpretable chemical and biological concentration contours. Except for the thermal bar period within the Rochester Embayment, the results of this study were severely condensed by cluster analysis to produce interpretable results.

The nutrient impact of three major United States tributaries to Lake Ontario was assessed. In each area, nutrient enrichment of the lake was found. Generally, the areal extent of the impact was relatively small and restricted to the mixing and nearshore areas within the areas monitored. During the first and fourth surveys, the Niagara River heavily influenced the mixing and nearshore areas of the Niagara River Plume study area.

The Rochester Embayment lake stations and the comparable areas of the Lake Ontario Surveillance network conducted by Environment Canada (Zones 12 and 13, Kwiatkowski 1982) showed the same seasonal patterns for total phosphorus with numerical agreement within 20%. Although the GLNPO survey results were higher during all surveys, the spring survey conducted by Environment Canada (4-27 to 5-1) which overlapped the GLNPO survey (4-29 to 5-4) had statistically the same total phosphorus concentrations (13.1-13.5 ug P/l) when compared to the GLNPO total phosphorus concentrations (14.3 ± 0.7 ug P/l). Kwiatkowski (1982) showed that the nutrient levels in the three nearshore areas had decreased in total phosphorus as much as 10 to 19 ug P/l since 1974, suggesting improved trophic conditions along the entire U.S. shoreline.

Maximum epilimnion DRS levels reported by Robertson and Scavia (1984) suggest that the spring diatom bloom had occurred prior to the first survey in late April. The open lake areas had surface DRS levels between 14 and 146.0 ug Si/l during April with a marked east to west increase in DRS concentrations occurring between Oswego and the Rochester Embayment. Shiomi and Chawla (1970) also showed a general east to west increase in nutrient concentrations.

Large variations in ammonia concentrations within the Niagara River (12.5 to 34 ug N/l), Genesee River (27.9 to 144 ug N/l) and Oswego River (60 to 188 ug N/l) suggest some municipal waste treatment plant and/or storm water overflow impacts. For example, ammonia levels in the Detroit River upstream from the Detroit municipal sewerage treatment plant outfall ranged from 6 to 7 ug N/l (GLNPO unpublished data). Downstream from the Detroit municipal sewage treatment plant outfall, the ammonia levels ranged from 27 to 176 ug N/l (GLNPO unpublished data). These downstream levels do not represent complete mixing in the Detroit River, whereas in the Niagara River the ammonia levels are presumably representative of the entire flow due to mixing at Niagara Falls. A 1 ug N/l increase in ammonia concentrations in the Niagara River would represent an additional load of about 1/2 metric ton ammonia per day.

During September, the greatest rainfall in the Syracuse and Rochester area occurred on September 21 and 22. This was just prior to the survey periods in the Rochester area. Measurable rainfall occurred at the Rochester National Weather Service Office on seven of the eleven days during the survey. Elevated total and soluble reactive phosphorus levels in the Genesee and Oswego Rivers during the fourth survey may be due to the runoff effects in the Rochester and Oswego areas.

In addition to elevated TP, SRP values were elevated during the third survey in the Genesee and Oswego Rivers, and during the second survey in the Oswego River. The continued presence of higher levels of TP and SRP in the source areas of the Rochester Embayment and the Oswego Harbor together with the high ammonia levels suggest adverse municipal plant impacts in the rivers.

Trace metal contamination in the water column was relatively minor. However, due to the occurrence of cadmium exceedances at 21% of the Rochester sites, additional investigations are suggested. Additional surveillance could consider potential sources, the areal extent and seasonal variation of the cadmium exceedances. Silver and aluminum were the only other metals which exceeded guidance criteria. Cadmium and silver exceedances were also reported by the NYDEC (Litten 1984).

High concentrations of chloride and sulfate, and elevated specific conductance were found in the Oswego River. Evidence suggests that loading was not intermittent since the biota were dominated by halophilic (salt loving) phytoplankton species within the Oswego Harbor and mouth of the Oswego River (Makarewicz, this report). A material handling facility was located near the river mouth with bulk storage facilities adjacent to the river bank. Road salt (NaCl) was stored unprotected in an open pile, and muriate of potash (KCl) had also been stored in this area (Oswego Port

Authority 1984). Seepage from this site could be a cause for the high levels of chloride, sulfate, and conductivity. Alternatively, downstream transport of water from Onondaga Lake, whose conductivity has been measured as 3000-6000 umhos/ cm (Litten 1984), may have influenced the conservative parameters at the mouth of the Oswego River.

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Phytoplankton Composition, Abundance and Distribution: Oswego River and Harbor and Niagara River Plume

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Oswego River drainage, 5,121 square miles, is the largest drainage area of the eastern part of Lake Ontario and is the second largest watershed in New York State. The drainage includes a variety of aquatic environments including seven of the Finger Lakes, Oneida Lake, Cross Lake and Onondaga Lake, among other smaller bodies of water. The Oswego River itself is only 24 miles long, originating at Three Rivers from a confluence of the Oneida River and Seneca River. Within the entire river system, there are approximately 7,000 miles of streams including 106 miles of barge canal. Flow in the Oswego River is regulated by a series of seven locks and dams, three of which are located in the town of Oswego (Jackson, Nemerow and Rand 1964).

The present project deals with a limited area of Lake Ontario and the Oswego River and Harbor at Oswego, New York (Figs. 1 and 2). This region lies within an area of Lake Ontario which has been extensively modified by factors which affect phytoplankton occurrence and abundance. Nutrients, chlorinated pesticides and PCB's flush into Lake Ontario via the Oswego River from domestic, agricultural and industrial sources in the extensive watershed. Several qualitatively different local sources are present, and the effects of these sources on phytoplankton composition and abundance are of interest because adjacent regions of the Lake are utilized for recreational purposes. In addition, one set of data from the Niagara River Plume is reported on here. This project was initiated by the United States Environmental Protection Agency, Great Lakes National Progam Office (GLNPO), to document the water quality of the Oswego River/Harbor and nearby inshore region of Lake Ontario.

The primary objectives of the project, which is part of a more comprehensive investigation, are the following:

1. To determine the composition and abundance of the phytoplankton flora for comparison with past conditions to the extent that they are known, and to provide firm documentation for comparison with future studies; and

2. To determine if there are patterns of occurrence for specific phytoplankton populations which may reflect the effect of specific sources.

METHODS AND MATERIALS

Phytoplankton samples were collected during three Oswego River cruises (July 31-August 1; August 30-September 2; October 8-10, 1981) and one Niagara River cruise (April 28-30, 1981) by GLNPO personnel (Fig. 1). An 8-liter PVC Niskin bottle mounted on a General Oceanics Rossette sampler with a guideline electrobathythermograph (EBT) was used. One-liter composite phytoplankton samples were obtained by compositing equal aliquots from samples collected at depths of 1 and 2 m above the bottom and at as many 5-meter intervals (5,10,15,20 m) as allowed by total water depth.

Phytoplankton samples were immediately preserved with 10 mL of Lugols solution. Up to two years later, 5-6% formaldehyde was added to each sample. The settling chamber procedure (Utermohl 1958) was used to identify (except for diatoms) and enumerate phytoplankton at a magnification of 500x. A second identification and enumeration of diatoms at 1250x was performed after the organic portion was concentrated and oxidized with 30% H_2O_2, HNO_3 and $K_2Cr_2O_7$ (EPA/CRL Method #B10201403). The cleaned diatom concentrate was air dried on a #1 cover slip and mounted on a slide (75x25mm) with HYRAX™ mounting medium. All identifications and counts were done by Bionetics, Inc.

The cell volume of each species was computed by applying average dimensions from each sampling station and date to the geometrical shapes that most closely resembled the species form, such as sphere, cylinder, prolate spheroid, etc. At least 10 specimens of each species were measured for the cell volume calculation. When fewer than 10 specimens were present, those present were measured as they occurred. For most organisms, the measurements were taken from the outside wall to outside wall. With loricated forms, the protoplast was measured, while the individual cells of filaments and colonial forms were measured.

Raw counts were converted to number/mL by GLNPO personnel. Abundances and dimensions of each species were entered into a Prime 750 computer using the INFO (Henco Software, Inc., 100 Fifth Avenue, Waltham, Mass.) data management system. Biovolumes (μm^3/mL) were calculated and placed into summaries for each sampling station containing density (cells/mL), biovolume (μm^3/mL) and relative abundance of species. In addition, each division was summarized by station. Summary information is stored on magnetic tape and is available for further analysis.

Overall Abundance of Major Algal Groups

Species lists and summary tables of abundance and biovolume by station and cruise are in the appendices 1-4. Original data sets are available from the Great Lakes National Program Office, Chicago, Illinois.

Oswego River and Harbor (Fig. 2)

Sampling stations were located in several different habitats including the Oswego River, the Oswego Harbor, a transient area between the Harbor and Lake Ontario (Harbor Entrance) and the nearshore of Lake Ontario. To facilitate analysis, the area has been divided by habitat type; that is, divided into Lake stations (Stations 12,13,17,19,22,23 and 29), Harbor Entrance stations (Stations 9 and 11) and Harbor stations (Stations 3,4,5,7,28 and 37). River station 3 is included with the Harbor stations.

The Oswego River, Harbor and nearshore Lake Ontario phytoplankton assemblage was composed of 469 alga taxa representing 115 genera from nine divisions: Bacillariophyta, Chloromonadophyta, Chlorophyta, Chrysophyta, Cryptophyta, Cyanophyta, Euglenophyta, Pyrrhophyta and Xanthophyta. The Chlorophyta possessed the largest number of taxa (191), while the second largest number were observed for the Bacillariophyta (163) (Table 1). The average density and biovolume was 53,340 cells/mL (range: 12,627 to 131,776) and 3.3mm^3/l (range: 0.67 to 13.2), respectively, for the entire study area.

From late July until mid-October, absolute abundance decreased slightly in the harbor, river and harbor entrance and decreased dramatically in the nearshore of Lake Ontario (Table 2). Harbor/River abundances were generally higher than lake densities. Highest overall densities were attained by the blue-green algae (87%), with greens, diatoms and cryptophytes secondarily abundant. All other algae accounted for only 2% of the total abundance (Table 3a). This pattern did not change between the lake, harbor entrance or harbor/river stations or with time. However, a different pattern emerged when relative abundance based on biovolume was considered. Diatoms attained the highest biovolume (37.0%) with cryptophytes and greens of secondary importance. Blue-greens represented only 4.5% of total biovolume of phytoplankton (Table 3b).

Regional and Seasonal Trends in the Abundance of Abundant Taxa

Bacillariophyta

Cyclotella cryptica Reimann, Lewin and Guillard (Table 4)

This species was originally described from a brackish-water habitat (Reimann *et al.* 1963). In Lake Michigan, most records of its occurrence come from harbors and inshore areas subject to elevated chloride level (Stoermer and Yang 1969). At Oswego, it was found in higher numbers in the harbor/river area relative to the lake stations in July, August and October. In July, this species was the dominant diatom (37% of total abundance), with a maximum density of 3050 cells/mL at Station 3 at the mouth of the Oswego River. In August, *C. cryptica* was also abundant at Station 22. This station is within a 1/4 mile of the shore.

Fragilaria crotonensis Kitton (Table 5)

This species is one of the most commonly reported plankton diatoms. It is present in all the Great Lakes and can tolerate a wide range of ecological conditions (Stoermer and Tuchman 1979). Densities were lowest in late July with a trend toward higher abundance from August to October. Densities appeared to be slightly higher in the nearshore of the lake than in the harbor or river.

Stephanodiscus tenuis Hust. (Table 6)

This species has been reported as dominant in collections from Lake Ontario (Nalewajko 1966). It was the second most abundant diatom (24%) during Cruise 2 and the dominant in Cruise 3 (21% of total diatoms). *S. tenuis* was observed in all samples but obviously was much more prevalent within the harbor and river, with the exception of lake Station 22. Abundances were greater in late August than in July or October. *S. tenuis* is apparently tolerant of fairly high levels of total dissolved solids (Stoermer and Ladewski 1976).

Cyclotella meneghiniana Kütz.(Table 7)

This species is widely distributed in both fresh and brackish waters (Stoermer and Ladewski 1976). General distribution records suggest that it is strongly halophilic, and some evidence indicates that it requires elevated TDS levels to successfully complete its life cycle (Stoermer and Ladewski 1976). Except for Station 22, the station within a 1/4 mile of the shore, abundances were lower at the lake stations than harbor and river stations. However, this species was dominant at the river and harbor stations (17% of the total diatom abundance) in October.

Fragilaria capucina Desm. (Table 8)

High population densities of *F. capucina* are usually associated with eutrophic or disturbed conditions in the Great Lakes (Stoermer and Ladewski 1976). It has been noted as being abundant in Lake Ontario by some investigators (Nalewajko 1966; Reinwand 1969). In 1972-73, it was abundant at scattered nearshore stations in Lake Ontario (Stoermer *et al.* 1975). Michalski (1968) indicated that it is more abundant in the Bay of Quinte than in Lake Ontario proper.

Abundance in the Oswego study area was low in July and August compared to October. In October, *F. capucina* reached densities of 1000 cells/mL at the harbor and river stations. This species represented 13% of the total diatom abundance in October.

Cyclotella atomus Hust. (Table 22)

Most reports of this species are from polluted harbors and nearshore localities (Stoermer and Ladewski 1976). It was occasionally the dominant diatom during this study; e.g., Stations 4 and 7 (Cruise 3) and Station 3 (Cruise 4). At other times, it was abundant (Stations 3,5 and 22; Cruise 3) but, in general, was not present in large numbers.

Cryptophyta

Cryptomonas erosa Ehr.(Table 9)

This member of the genus is widely distributed in the Great Lakes (Stoermer _et al._ 1975), usually in low numbers. According to Huber-Pestalozzi (1968), it is a eurytopic organism, occurring both in oligotrophic lakes and often, in abundance, in eutrophic and slightly saline habitats. Munawar and Nauwerck (1971) found it during all seasons in Lake Ontario during 1970, with greatest abundances in the spring and fall. Stoermer _et al._ (1975) observed large populations (100-250 cells/mL) at nearshore stations on the southern shore at the eastern part of the lake in June. Similar densities were observed in this study area in late July and October. In July, this species accounted for 63% of the Cryptophyta biovolume and 30.1% of the total algal biovolume.

Rhodomonas minuta v. nannoplanktica Skuja (Table 10)

The Ontario Ministry of the Environment has been monitoring phytoplankton in the outflow of Lake Ontario at Brockville in the St. Lawrence River since 1967. _Rhodomonas_ and _Cryptomonas_ species contributed only 5% of the total phytoplankton biomass in the late 1960's but had increased to over 30% by 1978 (Nicholls 1980). In 1981 at Oswego, abundances averaged 253 cells/mL ranging to a maximum of 1219 cells/mL at Station 29 in October. Abundances appeared to increase in October with this species, accounting for 42.8% of the total abundance (cells/mL) of Cryptophyta.

Chlorophyta

The four taxa listed below represented 29.7% of the total abundance (cells/mL) of green algae. The other 70.3% was comprised of 187 taxa, none of which comprised more than 25% of total abundance for a given sampling date and station.

Coelastrum microporum Nag. (Table 11)

Stoermer et al. (1975) reported this species as being widely distributed in the Great Lakes, but that it only reached appreciable abundance in eutrophic lakes. It has been reported from Irondequoit Bay, Lake Ontario (Tressler et al. 1953) and as a spring dominant in the open lake by Munawar and Nauwerck (1971). Stoermer et al. (1975) reported it as "quite abundant" (100-300 cells/mL) in the eastern half of Lake Ontario during August 1972.

In this study, abundances reaching 2130 cells/mL were observed in the nearshore lake station. Its density appeared to be higher in late August and October at the lake stations.

Scenedesmus spp. (Table 12)

Most species of Scenedesmus reported from the Great Lakes prefer eutrophic waters (Stoermer et al. 1975). Abundance was generally higher in the harbor and river stations than in the lake stations in this study.

Dictyosphaerium pulchellum Wood (Table 13)

This species is sometimes a conspicuous component of the plankton in acid bog lakes (Prescott 1973). At Oswego, abundance was higher in July and isolated to the harbor and river areas. In August, it was again observed only in the harbor and river, except for Station 22. By October, it had essentially disappeared.

Monoraphidium contortum (Thuret) Kom.-Legn. (Table 14)

This species was observed in both the harbor and river environments and the nearshore of Lake Ontario. A maximum density of 949 cells/mL was observed in late August at Station 3 in Oswego River.

Cyanophyta

Anacystis marina Dr. and Daily (Table 15)

A. marina is widely distributed as plankton in fresh, brackish, and sometimes marine waters. It is rarely reported, probably because it is easily overlooked (Humm and Wicks 1980). Cells range in size from 0.5-2.0 µm in diameter.

This was the dominant plankton within the study area representing 75% of the total algal abundance (cells/mL) but only approximately 1% of the total algal biovolume. Densities as high as 95,107 cells/mL were observed. In general, densities were higher in the harbor/river environment.

Apparently, there are no other reports of this species in Lake Ontario reaching the abundance observed in this study. Stoermer *et al.* (1975) observed *Anacystis cyanea* and *Anacystis incerta.* However, combined abundance never exceeded 1500 cells/mL. Since *A. cyanea* ranges in size from 3-7µm, it is unlikely that the species have been confused. *A. incerta* was observed in the present study, but it did not predominate.

Oscillatoria limnetica Lemm. (Table 16)

Stoermer *et al.* (1975) reported this species as the most common member of the genus in the 1972-73 collections. According to

Huber-Pestalozzi (1938), it is a common euplanktonic form which often occurs in polluted waters. Munawar and Nauwerck (1971) recorded it as being an abundant form in the fall plankton of Lake Ontario.

Relatively large populations of this species were noted in our collection (1.8% of the total algal abundance). Density was considerably higher in the river and harbor stations than in the lake stations in late August. The exception was Station 22 in the lake where abundance was noticeably higher than at other lake stations.

Anacystis montana f. minor Dr. and Daily (Table 17)

According to Humm and Wicks (1980), A. montana is planktonic and possesses a worldwide distribution in freshwater and also in brackish water habitats. At Oswego, abundance was high (1.8% of the total algal density) with a bimodal temporal distribution. In late August, it was essentially absent from the area, while in late July and October, it was present in the harbor, river and lake habitats.

Coccochloris peniocystis Kütz.(Table 18)

According to Humm and Wicks (1980), most reports of this species are from freshwater, but occassionally it is reported from marine habitats. It has a world-wide distribution. At Oswego, it was found throughout the study area with no obvious distributional pattern. It accounted for 1.8% of the total algal density for the study period.

Pyrrhophyta

Dinoflagellate density was generally low (range: 8-131 cells/mL). However, because of their large size, relative biomass was high for the study period (12.3%). Dinoflagellates were more prevalent in late July than in August or September with Ceratium hirundinella, Peridinium aciculiferum and Peridinium cinctum dominating at various stations with no obvious distributional pattern within the study area.

NIAGARA RIVER PLUME (FIG. 3)

The Niagara River Plume phytoplankton assemblage comprised 220 taxa within 68 genera from seven divisions: Bacillariophyta, Chlorophyta, Chrysophyta, Cryptophyta, Cyanophyta, Pyrrhophyta and Euglenophyta. The Bacillariophyta possessed 109 taxa, while the second largest number of taxa (46) were observed in the Chlorophyta (Table 20). The average density and biovolume was 59,587 cells/mL (range: 4910 to 180,290) and 1.2mm^3/l (range: 0.42 to 2.3), respectively.

Abundance was higher within the plume than outside the plume in this study (Fig. 4). In the spring of 1972, the phytoplankton biomass of the Niagara River Plume was reported lower than that of Lake Ontario (Great Lakes Laboratory 1976). This lower biomass was attributed to higher turbidity of the Niagara River. One major difference between the studies was in methodology. In the present study, samples from 1,5,10,15 and 20m (when possible) were composited and enumerated. In the 1972 study, samples were from 1m only.

Highest overall densities were attained by blue-green algae (96%) with Anacystis marina being the dominant species. Greens (1.1%), diatoms (1.2%) and cryptophytes (0.4%) were of less importance on a cells/mL basis (Table 21). With biovolume, a different pattern emerged. The diatoms were most abundant (54.9%) with the Pyrrhophyta accounting for 29.1% of the total biovolume (Table 21). During the spring of 1972, the Great Lakes Laboratory (1976) reported that diatoms accounted for over 50% of the biomass, with the Pyrrhophyta and Cryptophyta being the next two major categories.

Dominant species within the plume were Stephanodiscus hantzschii, *Stephanodiscus tenuis*, and *Anacystis marina* on a cells/mL basis. *Stephanodiscus niagarae*, *Tabellaria fenestrata*, *Cryptomonas erosa*, and *Peridinium aciculiferum* were most prevalent in the plume based on biovolume. Munawar and Munawar (1976), working on Lake Erie, reported that species of *Rhodomonas*, *Cryptomonas*, *Stephanodiscus tenuis*, *S. niagarae*, and *Peridinium aciculiferum* were predominant in the eastern basin during the spring and fall.

DISCUSSION

OSWEGO HARBOR

Phytoplankton assemblages observed in both the Oswego Harbor and River and nearshore of Lake Ontario were represented by many species which are widely recognized as associated with eutrophic and often halophilic environments. Diatoms (biovolume) and blue-greens (abundance) were the dominant groups of the phytoplankton assemblage.

Eutrophic Species

Oswego Harbor and the mouth of the Oswego River, in comparison to nearshore waters of Lake Ontario, were characterized by higher phytoplankton community abundance and more eutrophic species throughout most of the sampled periods. The following known eutrophic species were present in substantially higher abundance than in the nearshore region: *Stephanodiscus tenuis*, *Fragilaria capucina*, *Cryptomonas erosa* and *Scenedesmus spp*

Decreases in Asterionella and Tabellaria

Few historical studies of the phytoplankton of the Oswego River and Harbor apparently exist. Tressler and Austin (1940) sampled 11 stations in and outside the harbor at Oswego and at a station three miles off the mouth of the Oswego River in July of 1939. Methodology is not described for enumeration. Blue-green (3.1 cells/mL) and green algae (17 cells/mL) were scarce while diatom abundance averaged 148 cells/mL with *Asterionella* (104 cells/mL) and *Tabellaria* (86.5 cells/mL) being dominant at the lake station. At the river station, forms of *Navicula* became more important but did not supersede *Tabellaria.* Nalewajko (1966) also reported *Asterionella formosa* as being dominant in nearshore waters off Gibraltar Point in 1964-65.

In this study, abundance of *Asterionella* plus *Tabellaria* never exceeded 5 cells/mL in late July or 20 cells/mL in late August. Only in October did abundance of these genera reach densities observed in July of 1939. Nicholls (1980) also reports that since 1967, *Tabellaria spp.* have become less abundant in the outflow of Lake Ontario at Brockville on the St. Lawrence River. The composition of the outflow is a "blend" of nearshore and offshore lake water. A decrease in abundance of the historically prevalent diatoms *Asterionella* and *Tabellaria* is suggested.

Increases in Blue-green Algae

Blue-green algae were reported as scarce in the Oswego Harbor area in 1939 by Tressler and Austin (1940). With the standard analytical techniques of that period, it is unlikely that they would be able to collect and perhaps see *Anacystis marina* (0.5-2.0μm diameter) or probably any of the other species of *Anacystis* observed in this study. Thus it is extremely difficult to conclude without question that blue-green algae are more prevalent now than 40 years ago.

The overwhelming dominance of *Anacystis marina* in our lake, harbor and river samples is unique. Stoermer *et al.* (1975), Nalewajko

(1966,1967) and Munawar and Nauwerck (1971), using comparable methodologies in their major studies of the near and offshore water of Lake Ontario, did not report this species. The other species of _Anacystis_ previously observed in the lake were noted in this study. Why this species was not reported in earlier studies is not known. Because of its small size, it may simply not have been counted. Traditionally, these small objects have been relegated to the bacteria. More research is suggested elucidating the nature of the organisms.

Very large differences in the phytoplankton of nearshore Lake Ontario and the open lake are now known. Some of the inshore-offshore differences can be related to the effects of the thermal bar which develops within a distance of 1-10 km from shore during spring and early summer. However, after thermal stratification has developed, the nearshore environment is affected by other phenomena such as coastal jets and upwelling. Nicholls (1980) suggested that the blue-green algae are restricted to late fall with the common genera being _Aphanizomenon_, _Gomphosphaeria_, _Microcystis_, and _Anabaena_ in the open water. By contrast, in the nearshore area during this study, blue-greens were the most abundant algal division throughout the period of the study with _Anacystis_, _Oscillatoria_, and _Coccochloris_ being dominant.

Halophilic Species

Nicholls (1980) has discussed the arrival of new species to the phytoplankton of the Great Lakes. It is not clear whether these species are really recent invaders or if they have been long-time residents and have been overlooked in earlier studies because of their scarcity and often restricted and localized distribution. Most of the apparent new arrivals show definite halophilic tendencies in their known distribution in other parts of the world. In inshore and harbor areas, the increase in concentration of conservative elements, such as Cl^-, has conceivably created an environment more suitable for growth of halophilic species (Chawla 1971). With the discharge of sea water ballast in Lake Ontario by ocean-going ships, the opportunity for introduction of new species is great. Nicholls (1980) noted the following as new halophilic diatom species: Cyclotella atomus, Stephanodiscus subtilis,[1] Skeletonema subsalsum, Skeletonema potamos, Thalassiora fluviatilis, and Thalassiora pseudonana.

One of the more striking aspects of this study is the abundance of halophilic species within the Oswego River and Harbor (Table 23). During the sampling period, large piles of de-icing salt were observed stored on the waterfront of the Oswego River (Devault 1984). The central region of New York State, essentially the drainage basin of the Oswego River, commonly utilizes de-icing salt during the winter to remove ice and snow. However, the major chloride loading to the Oswego River and Lake Ontario is a chlor-alkali plant on Onondaga Lake (Effler et al. 1985). Outflow from Onondaga Lake eventually reaches the Oswego River. Chloride concentrations are high especially at river stations (Fig. 5).

In this study, Cyclotella atomus, Stephanodiscus subtilis and Skeletonema potamos were fairly abundant representing 10.8% of the mean total diatom abundance at the harbor and river stations. Maximum cell densities reached approximately 1300 cells/mL (Table 19). In late August the above halophilic species accounted for 14.2% of the total diatom abundance in the study area.

Cyclotella atomus, which is the prevalent species of the group found at Oswego, is known from several rivers and lakes in Germany, Java,

[1]The validity of this taxonomic concept is questionable. Consistency between labs has not been shown (Andresen,1985).

Sumatra, South Africa and coastal Scandinavian waters with salinities ranging up to 30% (Nicholls 1980). Sreenivasa and Nalewajko (1975) first reported it in samples from northeast Lake Ontario in 1965. More recent reports from Lakes Erie and Ontario have been made by Stoermer (1978), Stoermer and Kreis (1978) and Nicholls and Carney (1979).

Stephanodiscus subtilis is known from several rivers in Holland, from weakly saline waters near Stockholm and from the North Sea (Nicholls 1980). Stoermer *et al.* (1975) recorded *S. subtilis* from Lake Ontario for the first time from collections made in 1972. *Skeletonema potamos* has been grown in cultures over the full range of salinity from freshwater to saltwater.

In addition, the following known brackish, marine, and in general, halophilic species were observed: *Cyclotella cryptica*, *Cyclotella meneghiniana*, *Anacystis marina*, *Anacystis montana f. minor*, and *Coccochloris peniocystis*.

Station 22 (Fig. 2) was within 1/4 mile of the shore east of Oswego Harbor. Abundances of halophilic diatoms (e.g. *C. cryptica*, *S. tenuis* and *C. meneghiniana*) and dominant species were similar to those of the harbor rather than the nearshore of Lake Ontario. At present, we know of no sewage outfall or stream draining into the lake at this station. It is probable that the outflow of the Oswego River hugs the shoreline.

CONCLUSIONS

OSWEGO RIVER AND HARBOR

From the analysis of the phytoplanktonic distribution and abundance, the following conclusions are supported:

1. Blue-green algae were the dominant group on a cells/mL basis;
2. Diatoms were dominant on a biomass basis;

3. *Anacystis marina* was by far the dominant species, although it has not been reported in previous studies of the plankton of the lake;
4. Halophilic species dominated the diatom assemblage of Oswego Harbor and mouth of the Oswego River; and
5. Cryptomonads appeared to be increasing in number and *Asterionella* and *Tabellaria* were decreasing.
6. The water mass at Station 22 was not representative of a nearshore station. The phytoplankton assemblage indicated that harbor water was either moving or being trapped along the shoreline.

NIAGARA RIVER PLUME (FIG. 3)

From the analysis of the phytoplankton component, the following conclusions are supported:

1. Blue-green algae were the dominant group on a cells/mL comparison;
2. Diatoms were dominant with dinoflagellates of secondary importance on a biovolume basis;
3. *Anacystis marina* was the dominant species (cells/mL) and has not been reported in prior studies;
4. A plume of water from the Niagara River and Lake Erie entered Lake Ontario and was reflected by the phytoplankton assemblage. Phytoplankton species within the plume were similar to dominants from the eastern Lake Erie basin; and
5. Biomass within the plume was higher than that in adjacent Lake Ontario water. This is the opposite of what was found in 1972 by Great Lakes Laboratory (Great Lakes

Laboratory 1976).

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TABLE 1. Number of taxa and genera observed in each algal division or grouping, Oswego River and Harbor.

	Taxa	Genera
Chlorophyta	191	48
Bacillariophyta	163	27
Cyanophyta	29	12
Cryptophyta	29	3
Chrysophyta	27	13
Pyrrophyta	14	4
Colorless flagellates	6	3
Euglenophyta	5	3
Unidentified	3	-
Chloromonadophyta	1	1
Xanthophyta	1	1
TOTAL	457	117

TABLE 2. Mean phytoplankton density as cells/mL in the Oswego River, Harbor Entrance and nearshore region of Lake Ontario during summer 1981. Values in parentheses are number of stations sampled.

	Cruise 2 7/30 to 8/1	Cruise 3 8/30 to 9/2	Cruise 4 10/8 to 10/10
Lake	73,298 (2)	30,076 (12)	35,056 (5)
Harbor Entrance	60,624 (2)	61,909 (2)	49,128 (1)
Harbor/River	80,924 (4)	81,387 (6)	70,766 (6)

Stations 3,4,5,7,28 and 37 are in the Harbor/River area. Stations 9 and 11 are at the mouth or passageway through the breakwater. All other stations are lake samples (Fig. 2).

Table 3. Relative abundance of major phytoplankton divisions in the Oswego River, Harbor Entrance and nearshore region of Lake Ontario during summer 1981. (3a) Values are percent of total cells/liter. (3b) Values are percent of total biovolume/mL.

3a

	CHL (%)	BAC (%)	CRY (%)	CYA (%)	PYR (%)	Other (%)
CRUISE 2						
Lake	2.11	0.47	0.74	95.78	0.01	0.89
Harbor Entrance	2.97	0.87	1.17	93.99	0.01	0.99
Harbor/River	9.68	5.10	0.91	83.48	0.03	0.80
CRUISE 3						
Lake	7.24	4.12	3.36	80.55	0.01	4.73
Harbor Entrance	4.57	1.37	1.59	88.84	2.70	0.94
Harbor/River	6.48	5.65	1.06	84.83	0.13	1.84
CRUISE 4						
Lake	6.11	3.57	4.16	84.26	0.01	1.89
Harbor Entrance	4.20	4.60	1.83	87.99	0.03	1.36
Harbor/River	5.04	4.96	0.73	87.60	0.01	1.67
MEAN	5.38	3.41	1.72	87.48	0.32	1.69

3b

	CHL (%)	BAC (%)	CRY (%)	CYA (%)	PYR (%)	Other (%)
CRUISE 2						
Lake	12.62	2.99	77.09	2.15	3.70	1.45
Harbor Entrance	10.40	6.34	78.41	2.95	0.54	1.36
Harbor/River	40.39	25.55	25.56	2.16	1.95	4.39
CRUISE 3						
Lake	20.71	26.67	6.85	15.06	28.74	1.97
Harbor Entrance	47.97	18.93	8.04	4.01	17.95	3.10
Harbor/River	17.60	43.62	2.63	6.18	27.64	2.33
CRUISE 4						
Lake	14.50	63.44	10.35	1.40	9.89	0.42
Harbor Entrance	23.94	56.72	12.66	4.95	0.28	1.45
Harbor/River	5.44	88.27	3.82	1.18	0.70	0.59
MEAN	21.51	36.95	25.05	4.45	10.15	1.89

TABLE 4. Distribution and abundance (cells/mL) of *Cyclotella cryptica.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	3050	852	248
4	1843	690	137
5	2811	465	301
7	1401	834	162
28	NS	286	274
37	NS	109	211
Harbor Entrance			
9	160	125	NS
11	14	NS	130
Lake			
12	69	72	NS
13	183	17	NS
17	NS	27	14
19	NS	17	8
22	NS	356	56
23	NS	NS	26
29	NS	121	9

TABLE 5. Distribution and abundance (cells/mL) of *Fragillaria crotonensis.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	0.0	5.5	54
4	2.8	156	85
5	0.0	58	105
7	2.5	19	129
28	NS	146	94
37	NS	209	114
Harbor Entrance			
9	51	414	NS
11	6.0	NS	62
Lake			
12	0.0	64	NS
13	4.7	234	NS
17	NS	241	226
19	NS	145	119
22	NS	170	215
23	NS	NS	257
29	NS	113	293

TABLE 6. Distribution and abundance (cells/mL) of *Stephanodiscus tenuis*, *S. tenuis* v. 1 and *S. tenuis* v. 2.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	790	875	521
4	691	1035	533
5	556	1123	870
7	458	1538	303
28	NS	695	756
37	NS	346	262
Harbor Entrance			
9	199	323	NS
11	128	NS	309
Lake			
12	76	287	NS
13	124	151	NS
17	NS	201	91
19	NS	75	55
22	NS	2204	204
23	NS	NS	150
29	NS	261	138

TABLE 7. Distribution and abundance (cells/mL) of *Cyclotella meneghiniana*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	356	662	539
4	21	334	790
5	334	310	712
7	195	249	368
28	NS	168	953
37	NS	69	331
Harbor Entrance			
9	29	49	NS
11	12	NS	328
Lake			
12	3.1	37	NS
13	16	13	NS
17	NS	51	20
19	NS	6.8	25
22	NS	140	250
23	NS	NS	131
29	NS	77	65

TABLE 8. Distribution and abundance (cells/mL) of *Fragilaria capucina.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	13	5.5	359
4	28	16	610
5	0	0	536
7	0	9.7	426
28	NS	40	1010
37	NS	23	356
Harbor Entrance			
9	38	36	NS
11	2.3	NS	200
Lake			
12	0	64	NS
13	0.9	6	NS
17	NS	29	38
19	NS	19	119
22	NS	0	260
23	NS	NS	302
29	NS	13	98

TABLE 9. Distribution and abundance (cells/mL) of *Cryptomonas erosa.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	155	16	33
4	106	25	123
5	61	16	66
7	220	25	74
28	NS	16	131
37	NS	33	0
Harbor Entrance			
9	311	0	NS
11	368	16	41
Lake			
12	180	41	NS
13	294	57	NS
17	NS	33	123
19	NS	33	90
22	NS	25	139
23	NS	NS	196
29	NS	41	106

TABLE 10. Distribution and abundance (cells/mL) of *Rhodomonas minuta v. nannoplanktica.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	131	16	221
4	82	229	164
5	491	139	139
7	115	82	327
28	NS	220	138
37	NS	205	82
Harbor Entrance			
9	82	49	NS
11	74	90	466
Lake			
12	49	74	NS
13	57	205	NS
17	NS	172	728
19	NS	213	417
22	NS	245	826
23	NS	NS	590
29	NS	254	1219

TABLE 11. Distribution and abundance (cells/mL) of *Coelastrum microporum*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	0	74	98
4	491	286	123
5	675	622	0
7	662	90	237
28	NS	0	556
37	NS	115	196
Harbor Entrance			
9	131	0	NS
11	0	761	605
Lake			
12	262	229	NS
13	33	1464	NS
17	NS	589	33
19	NS	204	262
22	NS	965	262
23	NS	NS	2130
29	NS	196	1325

TABLE 12. Distribution and abundance (cells/mL) of <u>Scenedesmus</u> spp NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	1448	56	393
4	826	49	409
5	1287	270	736
7	548	638	196
28	NS	515	311
37	NS	180	417
Harbor Entrance			
9	196	131	NS
11	221	139	155
Lake			
12	33	33	NS
13	74	98	NS
17	NS	66	164
19	NS	57	164
22	NS	442	139
23	NS	NS	33
29	NS	204	41

TABLE 13. Distribution and abundance (cells/mL) of *Dictyosphaerium pulchellum*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	515	393	0
4	745	695	33
5	2037	515	0
7	278	622	0
28	NS	0	0
37	NS	0	0
Harbor Entrance			
9	0	344	NS
11	0	25	33
Lake			
12	0	0	NS
13	0	0	NS
17	NS	0	0
19	NS	0	180
22	NS	131	0
23	NS	NS	196
29	NS	0	0

TABLE 14. Distribution and abundance (cells/mL) of *Monoraphidium contortum*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	221	949	172
4	164	352	164
5	258	393	188
7	180	515	164
28	NS	229	164
37	NS	139	123
Harbor Entrance			
9	589	33	NS
11	552	82	41
Lake			
12	482	57	NS
13	581	49	NS
17	NS	25	16
19	NS	0	25
22	NS	262	98
23	NS	NS	0
29	NS	57	49

TABLE 15. Distribution and abundance (cells/mL) of *Anacystis marina*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	60,517	97,291	49,832
4	55,436	48,196	55,166
5	72,208	62,628	52,082
7	51,124	60,541	47,443
28	NS	42,624	95,107
37	NS	28,831	37,306
Harbor Entrance			
9	41,839	25,591	NS
11	55,506	73,909	38,182
Lake			
12	77,771	19,414	NS
13	53,742	23,726	NS
17	NS	26,205	20,265
19	NS	17,254	28,209
22	NS	39,826	23,456
23	NS	NS	29,755
29	NS	24,462	28,896

TABLE 16. Distribution and abundance (cells/mL) of *Oscillatoria limnetica.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	534	7543	581
4	245	6848	687
5	835	4483	164
7	442	8950	712
28	NS	3043	1293
37	NS	262	188
Harbor Entrance			
9	0	679	NS
11	491	1064	180
Lake			
12	0	98	NS
13	254	245	NS
17	NS	393	0
19	NS	0	205
22	NS	4794	0
23	NS	NS	5.7
29	NS	1350	0

TABLE 17. Distribution and abundance (cells/mL) of *Anacystis montana f. minor.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	4991	0	646
4	2888	0	4042
5	1289	0	1178
7	1129	0	1252
28	NS	0	1546
37	NS	0	834
Harbor Entrance			
9	1170	0	NS
11	3240	0	1317
Lake			
12	802	0	NS
13	1473	409	NS
17	NS	0	990
19	NS	0	614
22	NS	0	344
23	NS	NS	4868
29	NS	0	1113

TABLE 18. Distribution and abundance (cells/mL) of *Coccochloris peniocystis.* NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	205	319	74
4	2127	311	622
5	221	352	155
7	1513	417	1162
28	NS	1325	2012
37	NS	728	147
Harbor Entrance			
9	3019	687	NS
11	6504	1121	131
Lake			
12	3902	417	NS
13	2029	769	NS
17	NS	589	57
19	NS	188	33
22	NS	2225	90
23	NS	NS	540
29	NS	581	376

TABLE 19. Distribution and abundance (cells/mL) of *Cyclotella atomus* Hust. *Stephanodiscus subtilis* Van Goor and *Skeletonema potamos* (Weber) Halse. NS = No Sample. Values in parentheses represent the percent of the total abundance of diatoms at each station.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	356 (6.3%)	740 (11.8%)	468 (14.0%)
4	253 (7.8%)	776 (13.5%)	121 (3.5%)
5	329 (6.9%)	638 (13.6%)	324 (8.1%)
7	134 (6.0%)	1331 (22.0%)	115 (6.5%)
28	NS	522 (18.8%)	283 (5.2%)
37	NS	290 (16.6%)	297 (11.7%)
	$\bar{x}$ = 6.8%	$\bar{x}$ = 16.05%	$\bar{x}$ = 8.2%
Harbor Entrance			
9	22 (3.0%)	188 (11.0%)	NS
11	28 (3.8%)	NS	329 (14.3%)
Lake			
12	16 (3.3%)	137 (13.9%)	NS
13	15 (6.8%)	107 (13.2%)	NS
17	NS	147 (12.0%)	40 (5.0%)
19	NS	48 (11.6%)	16 (4.8%)
22	NS	1323 (19.8%)	69 (1.9%)
23	NS	NS	70 (4.5%)
29	NS	213 (14.2%)	32 (2.7%)

TABLE 20. Number of taxa and genera observed in each algal division or grouping, Niagara River.

	Taxa	Genera
Chlorophyta	46	20
Bacillariophyta	109	21
Cyanophyta	6	3
Cryptophyta	25	5
Chrysophyta	16	10
Pyrrhophyta	7	3
Colorless flagellates	8	4
Euglenophyta	2	2
Unidentified	1	-
TOTAL	220	68

TABLE 21. Relative abundance of major phytoplankton divisions in the Niagara River Plume. Values are percent of total cells/mL or biovolume/mL.

	CHL	BAC	CYA	CRY	PYR	Other
Mean (cells)	1.1%	1.2%	96%	0.4%	0.06%	1.2%
Mean (biovolume)	3.3%	54.9%	1.4%	7.5%	29.1%	3.8%

TABLE 22. Distribution and abundance (cells/mL) of *Cyclotella atomus*. NS = No Sample.

Station #	Cruise 2	Cruise 3	Cruise 4
Harbor/River			
3	186	628	370
4	107	754	88
5	153	538	236
7	130	1093	108
28	NS	387	237
37	NS	165	219
Harbor Entrance			
9	9.4	122	NS
11	6.9	NS	245
Lake			
12	16	106	NS
13	4.1	61	NS
17	NS	79	20
19	NS	17	19
22	NS	827	49
23	NS	NS	51
29	NS	159	12

TABLE 23. Distribution of halophytic plankton near Oswego, N.Y. Values represent the mean±S.E.

	CRUISE 2		CRUISE 3		CRUISE 4	
	Halophytes (cells/mL)	Conductivity (µmhos/cm)	Halophytes (cells/mL)	Conductivity (µmhos/cm)	Halophytes (cells/mL)	Conductivity (µmhos/mL)
Harbor	6361±908 (n=4)	654±59	2130±536 (n=6)	668±86	3251±674 (n=6)	746±48
Plume	7094±1905 (n=2)	403±39	2547±1059 (n=2)	370±17	2893±1169 (n=3)	469±12
Lake	4219±356 (n=2)	326±2.6	815±160 (n=5)	329±4.4	1138±212 (n=3)	327±3.1

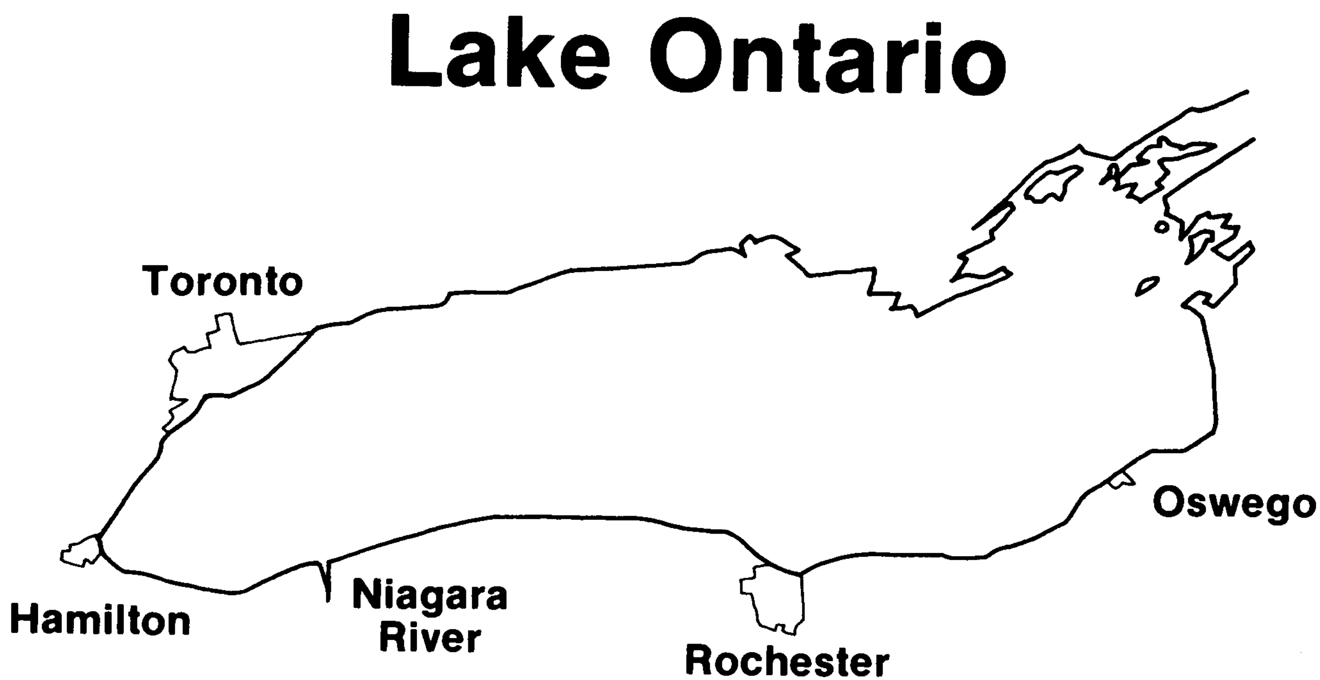


Figure 1 Lake Ontario showing the Oswego and Niagara phytoplankton sampling sites.

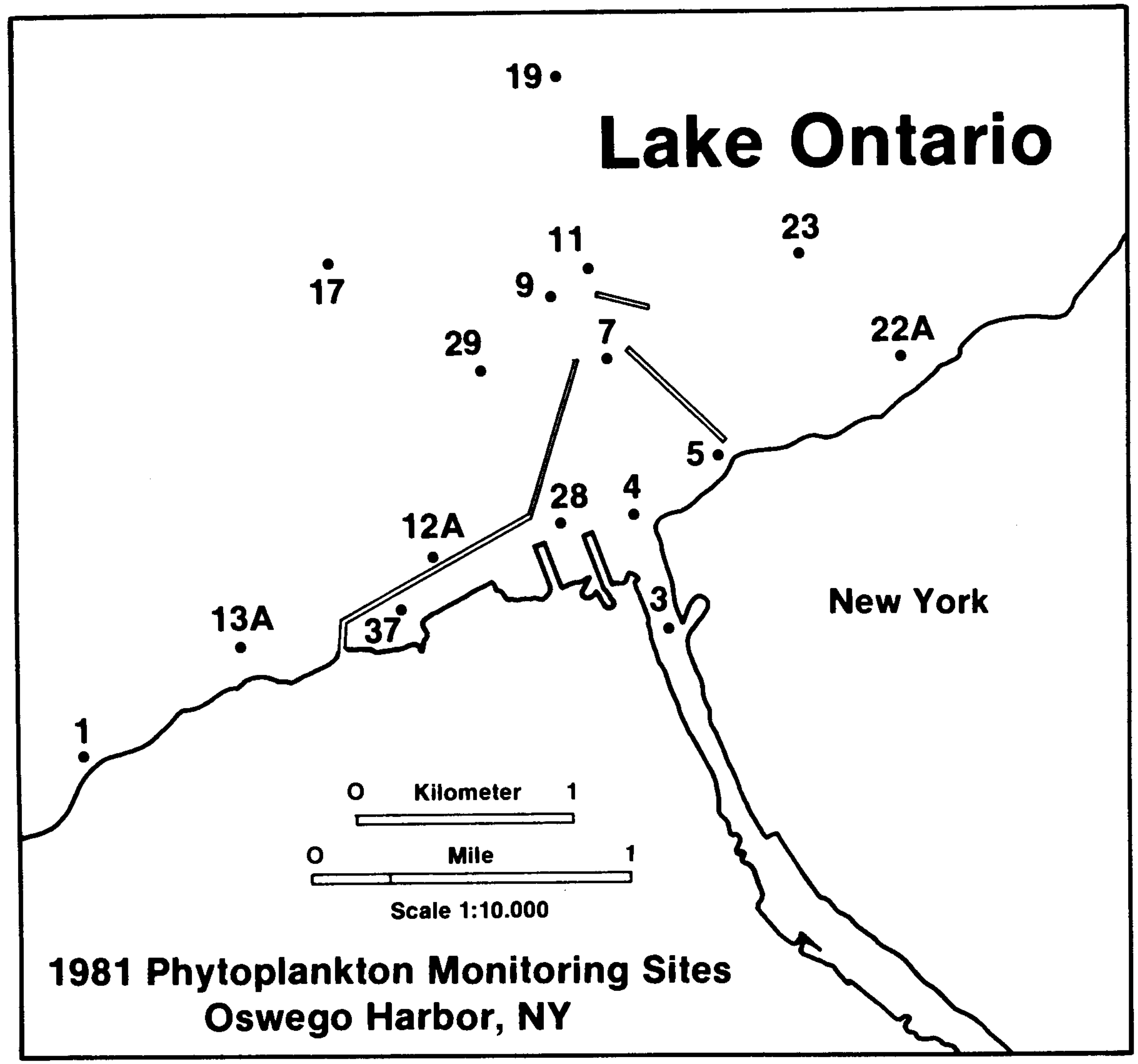


Figure 2 Phytoplankton sampling stations at Oswego, New York.

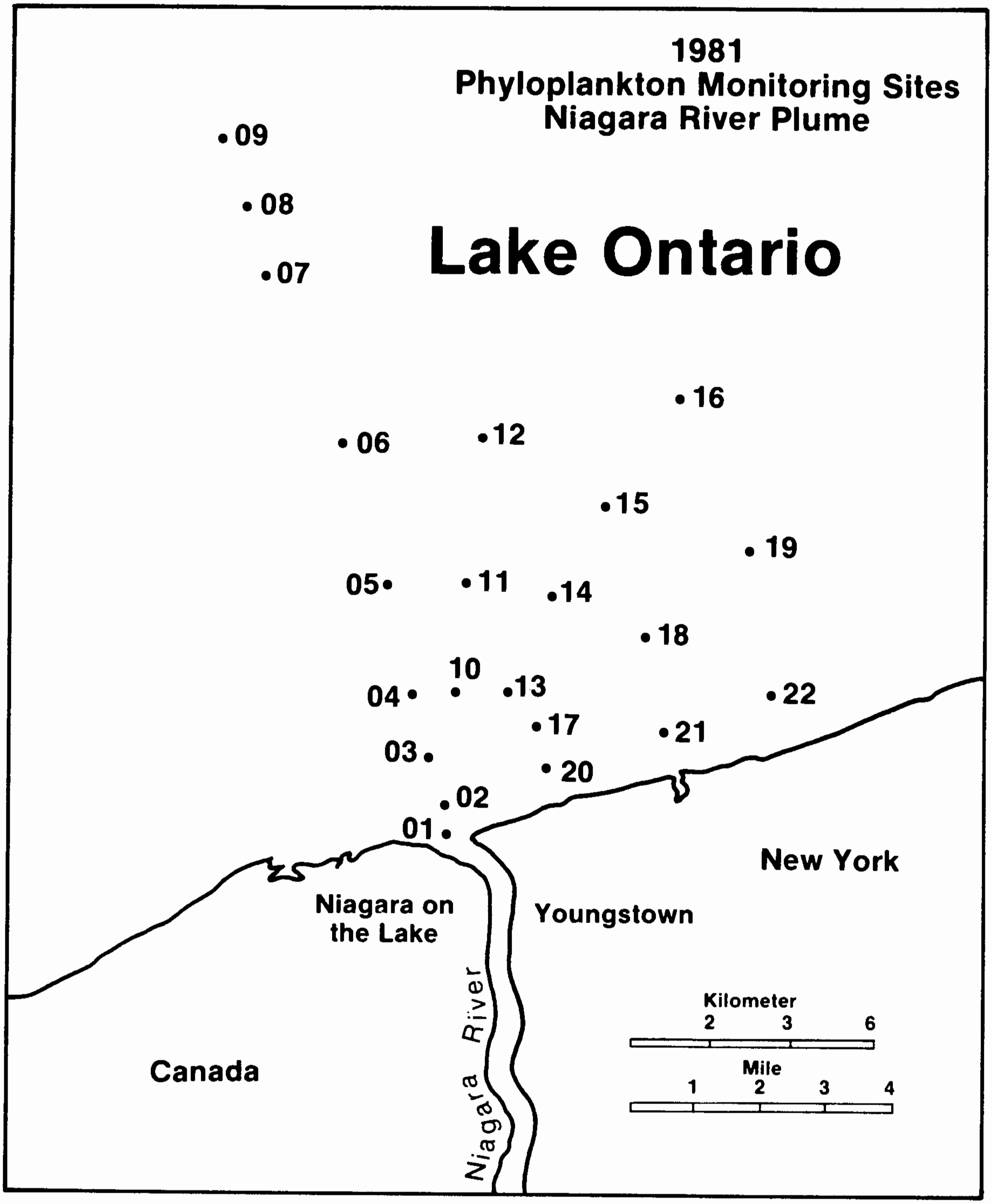


Figure 3 Phytoplankton sampling stations near the Niagara River.

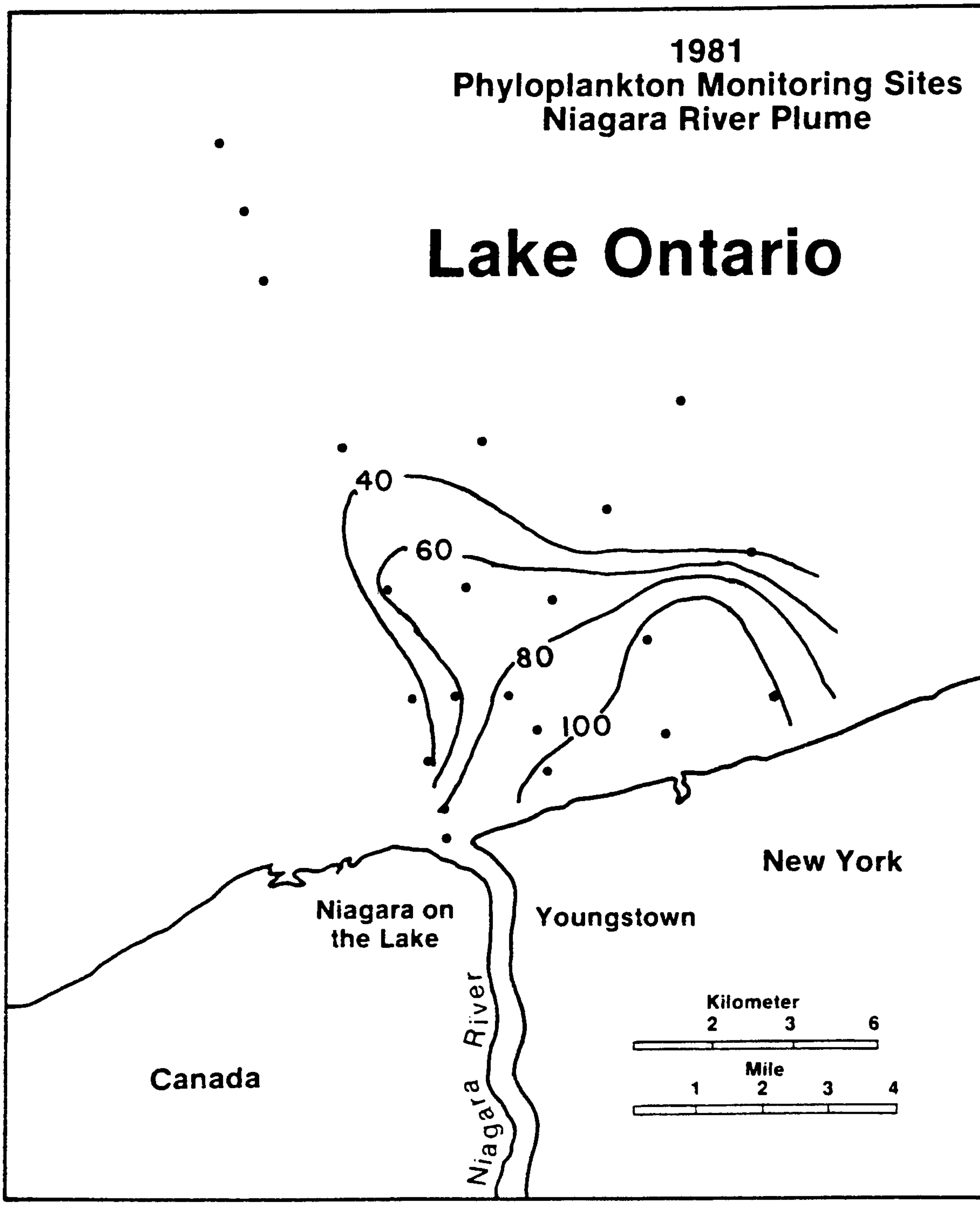
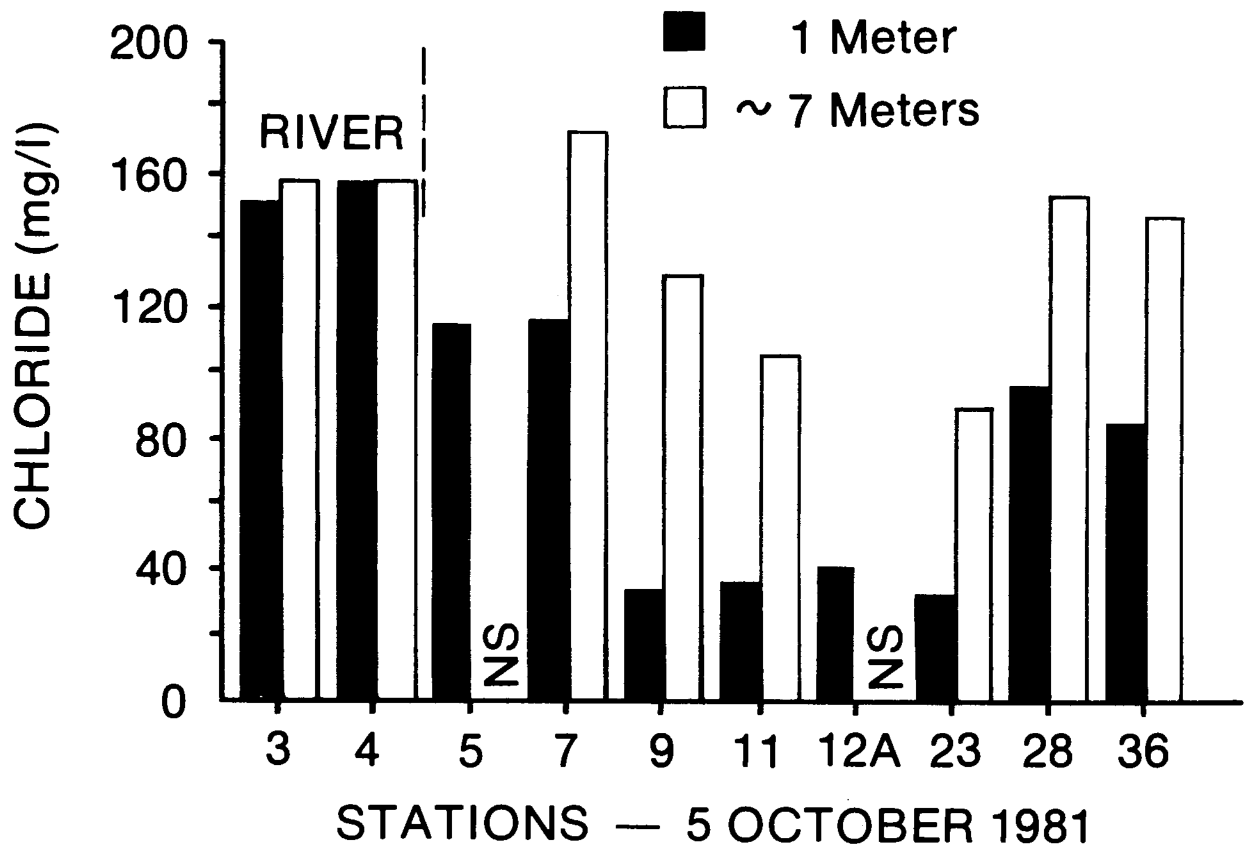


Figure 4 Isopleths of phytoplankton abundance (x10^3cells/mL), Niagara River Plume.



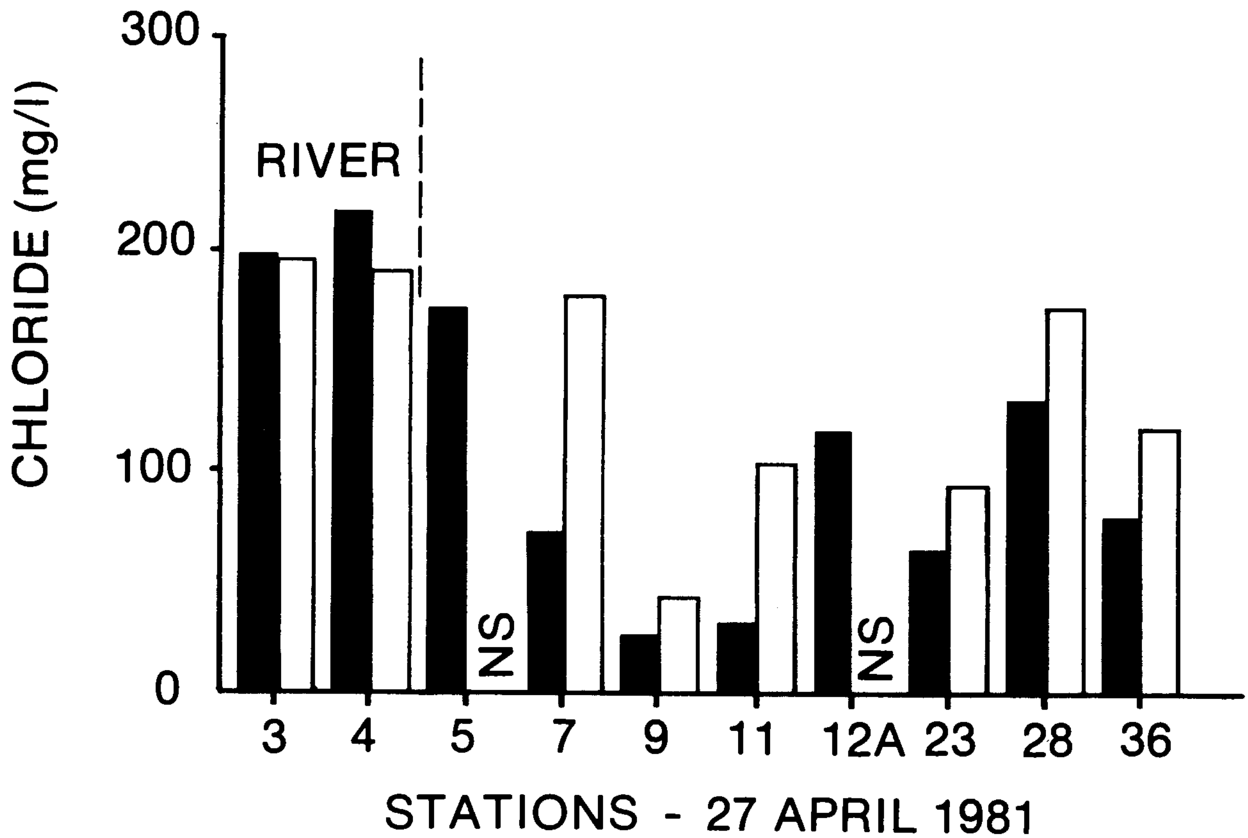


Figure 5 Chloride concentration in the Oswego River and Harbor and nearshore of Lake Ontario.

APPENDICES

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Achnanthes clevei
	Achnanthes coarctata v. elliptica
	Achnanthes conspicua
	Achnanthes exigua v. constricta
	Achnanthes hauckiana
	Achnanthes lanceolata v. dubia
	Achnanthes linearis
	Achnanthes linearis fo. curta
	Achnanthes minutissima
	Achnanthes sp.
	Actinocyclus normanii f. subsalsa
	Amphipleura rutilans?
	Amphora calumetica
	Amphora ovalis
	Amphora perpusilla
	Amphora sabiniana
	Amphora submontana?
	Asterionella formosa
	Caloneis bacillum
	Cocconeis diminuta
	Cocconeis disculus
	Cocconeis pediculus
	Cocconeis placentula
	Cocconeis placentula v. euglypta
	Cocconeis placentula v. lineata
	Coscinodiscus lacustris
	Cyclotella atomus
	Cyclotella comensis
	Cyclotella comensis v. 1
	Cyclotella comta
	Cyclotella cryptica
	Cyclotella cryptica?
	Cyclotella meneghiniana
	Cyclotella ocellata
	Cyclotella pseudostelligera
	Cyclotella sp.
	Cyclotella stelligera
	Cymbella cistula
	Cymbella minuta
	Cymbella prostrata
	Cymbella prostrata v. auerswaldii
	Cymbella sp.
	Diatoma tenue
	Diatoma tenue v. elongatum
	Diploneis oculata
	Eunotia sp.
	Fragilaria brevistriata
	Fragilaria capucina
	Fragilaria capucina v. mesolepta
	Fragilaria construens

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Fragilaria construens v. venter
	Fragilaria crotonensis
	Fragilaria pinnata
	Fragilaria sp.
	Fragilaria vaucheriae
	Gomphonema dichotomum
	Gomphonema olivaceum
	Gomphonema parvulum
	Gomphonema sp.
	Gyrosigma attenuatum
	Gyrosigma exilis ?
	Gyrosigma sciotense
	Gyrosigma spencerii
	Melosira distans
	Melosira granulata
	Melosira granulata v. angustissima
	Melosira italica
	Melosira italica subsp. subarctica
	Melosira varians
	Navicula anglica
	Navicula anglica v. subsalsa
	Navicula capitata
	Navicula cryptocephala
	Navicula cryptocephala v. veneta
	Navicula frugalis?
	Navicula gastrum v. signata
	Navicula gregaria
	Navicula heufleri v. leptocephala
	Navicula lanceolata
	Navicula meniscus v. upsaliensis
	Navicula omissa?
	Navicula pupula v. mutata
	Navicula pygmaea
	Navicula radiosa v. tenella
	Navicula reinhardtii
	Navicula salinarum v. intermedia
	Navicula seminulum
	Navicula sp.
	Navicula subhamulata
	Navicula submuralis
	Navicula tripunctata
	Navicula tripunctata v. schizonemoides
	Navicula viridula
	Navicula vulpina
	Neidium iridis v ampliatum
	Nitzschia acicularioides
	Nitzschia acicularis
	Nitzschia agnewii?
	Nitzschia amphibia
	Nitzschia angustata v. acuta

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Nitzschia bacata
	Nitzschia capitellata
	Nitzschia closterium
	Nitzschia confinis
	Nitzschia dissipata
	Nitzschia fonticola
	Nitzschia frustulum
	Nitzschia frustulum ?
	Nitzschia gandersheimiensis
	Nitzschia graciliformis
	Nitzschia gracilis
	Nitzschia impressa
	Nitzschia intermedia
	Nitzschia Kuetzingiana?
	Nitzschia lacuum?
	Nitzschia lauenburgiana
	Nitzschia palea
	Nitzschia palea v. debilis
	Nitzschia pumila
	Nitzschia pura
	Nitzschia recta
	Nitzschia romana
	Nitzschia rostellata
	Nitzschia sociabilis
	Nitzschia sp.
	Nitzschia sp. #04
	Nitzschia spiculum
	Nitzschia sublinearis
	Rhoiocosphenia curvata
	Skeletonema potamos
	Skeletonema sp. #01
	Skeletonema sp. #02
	Stephanodiscus alpinus
	Stephanodiscus binderanus
	Stephanodiscus binderanus v. oestrupii
	Stephanodiscus hantzschii
	Stephanodiscus minutus
	Stephanodiscus niagarae
	Stephanodiscus sp.
	Stephanodiscus sp. #03
	Stephanodiscus sp. #04
	Stephanodiscus subtilis
	Stephanodiscus subtilis?
	Stephanodiscus tenuis
	Stephanodiscus tenuis v. #01
	Stephanodiscus tenuis v. #02
	Surirella ovata
	Surirella ovata v. salina
	Synedra acus
	Synedra amphicephala v. austrica

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Synedra delicatissima
	Synedra delicatissima v. angustissima
	Synedra filiformis
	Synedra filiformis v. exilis
	Synedra miniscula
	Synedra parasitica
	Synedra parasitica v. subconstricta
	Synedra radians
	Synedra ulna
	Tabellaria fenestrata
	Tabellaria flocculosa
	Thalassiosira weissflogii
	Thalassiosira weissflogii?
CHLOROMONADOPHYTA	Vacuolaria sp.
CHLOROPHYTA	Actinastrum hantzschii
	Ankistrodesmus falcatus
	Ankistrodesmus falcatus?
	Ankistrodesmus sp.
	Ankistrodesmus sp. #02
	Ankistrodesmus sp.?
	Ankyra judayi
	Carteria cordiformis
	Carteria cordiformis?
	Carteria sp.
	Carteria sp. -ovoid
	Carteria sp. -sphere
	Chlamydocapsa planktonica
	Chlamydocapsa sp.
	Chlamydomonas globosa
	Chlamydomonas globosa?
	Chlamydomonas macroplastida
	Chlamydomonas securis?
	Chlamydomonas sp.
	Chlamydomonas sp. - ovoid
	Chlamydomonas sp. - sphere
	Chlamydomonas upsaliensis?
	Chlorella sp.
	Chlorococcallean - oval
	Chlorococcallean - sphere
	Closteriopsis longissima?
	Closteriopsis sp.
	Closterium aciculare
	Closterium gracile
	Closterium sp.
	Coelastrum cambricum
	Coelastrum microporum
	Coelastrum sp.
	Coelastrum sphaericum

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CHLOROPHYTA	Cosmarium botrytis?
	Cosmarium sp
	Cosmarium subcostatum
	Cosmarium tinctum v tumidum
	Crucigenia irregularis
	Crucigenia quadrata
	Crucigenia rectangularis
	Crucigenia sp. 1
	Crucigenia tetrapedia
	Crucigenia truncata
	Dictyosphaerium ehrenbergianum
	Dictyosphaerium infusionum
	Dictyosphaerium pulchellum
	Echinosphaerella limnetica
	Elakatothrix gelatinosa
	Elakatothrix viridis
	Eudorina elegans
	Eudorina sp.
	Franceia droescheri
	Franceia ovalis
	Gloedactinium limneticum
	Golenkinia radiata
	Golenkinia radiata v. brevispina
	Gonatozygon pilosum
	Gonium sp.
	Green coccoid
	Green coccoid #04
	Green coccoid - acicular
	Green coccoid - bacilliform
	Green coccoid - bicells
	Green coccoid - cylindrical
	Green coccoid - fusiform
	Green coccoid - fusiform bicells
	Green coccoid - oocystis-like bicell
	Green coccoid - oval
	Green coccoid - ovoid
	Green coccoid - sphere
	Green coccoid - sphere (large)
	Green flagellate - ovoid
	Kirchneriella contorta
	Kirchneriella contorta ?
	Kirchneriella lunaris
	Kirchneriella sp.
	Kirchneriella sp. ?
	Lagerheimia ciliata
	Lagerheimia citriformis
	Lagerheimia genevensis
	Lagerheimia longiseta
	Lagerheimia quadriseta
	Lagerheimia subsalsa

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CHLOROPHYTA	Lagerheimia wratislawiensis
	Lobomonas sp.
	Mesostigma sp.
	Micractinium pusillum
	Micractinium sp. #1
	Micratinium sp.
	Monoraphidium Braunii
	Monoraphidium Braunii?
	Monoraphidium contortum
	Monoraphidium irregulare
	Monoraphidium minutum
	Monoraphidium pusillum
	Monoraphidium saxatile
	Monoraphidium setiformae
	Monoraphidium setiformae?
	Monoraphidium sp.
	Monoraphidium tortile
	Mougeotia sp.
	Nephrocytium limneticum
	Oedogonium sp.
	Oocystis sp.
	Oocystis sp. #1
	Oocystis borgei
	Oocystis crassa
	Oocystis lacustris
	Oocystis marsonii
	Oocystis parva
	Oocystis pusilla
	Oocystis submarina
	Pandorina morum
	Pandorina morum?
	Paradoxia multiseta
	Pediastrum boryanum
	Pediastrum duplex
	Pediastrum duplex v. clathratum
	Pediastrum simplex
	Pediastrum simplex v. duodenarium
	Pediastrum sp.
	Pediastrum tetras
	Pediastrum tetras v. tetradon
	Phacotus sp.
	Phythelios sp. -oval
	Planktonema sp.
	Pteromonas angulosa
	Pteromonas angulosa?
	Pteromonas sp.
	Quadrigula closteriodes
	Quadrigula sp.
	Scenedesmus acuminatus
	Scenedesmus acuminatus v. elongatus

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CHLOROPHYTA	Scenedesmus acuminatus v. tortuosus
	Scenedesmus acutus
	Scenedesmus acutus f. costulatus
	Scenedesmus acutus v. alternans
	Scenedesmus anomalus ?
	Scenedesmus arcuatus
	Scenedesmus armatus
	Scenedesmus armatus v. bicaudatus
	Scenedesmus bicaudatus
	Scenedesmus bicaudatus v. brevicaudatus
	Scenedesmus brevispina
	Scenedesmus denticulatus
	Scenedesmus denticulatus v. caudatus
	Scenedesmus denticulatus v. linearis
	Scenedesmus dispar
	Scenedesmus ecornis
	Scenedesmus ecornis v. disciformis
	Scenedesmus intermedius
	Scenedesmus intermedius v. acaudatus
	Scenedesmus intermedius v. balatonicus
	Scenedesmus intermedius v. bicaudatus
	Scenedesmus opoliensis
	Scenedesmus pecsensis
	Scenedesmus quadricauda
	Scenedesmus quadricauda v. longspina
	Scenedesmus quadricauda v. maximus
	Scenedesmus quadricauda v. quadrispina
	Scenedesmus securiformis
	Scenedesmus serratus
	Scenedesmus sp.
	Scenedesmus spinosus
	Scenedesmus spinosus?
	Schroederia setigera
	Sphaerocystis schroeteri
	Staurastrum contortum
	Staurastrum cuspidatum
	Staurastrum lacustre
	Staurastrum megacanthum
	Staurastrum paradoxum
	Staurastrum paradoxum v. parvum
	Staurastrum sp.
	Tetraedron akinete
	Tetraedron caudatum
	Tetraedron caudatum v. longispinum
	Tetraedron minimum
	Tetraedron muticum
	Tetraedron regulare
	Tetraedron regulare v. incus
	Tetraedron sp.
	Tetraedron trigonum

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CHLOROPHYTA	Tetraedron victoriae v. ?
	Tetrastrum glabrum
	Tetrastrum heteracanthum
	Tetrastrum staurogeniaeforme
	Treubaria crassispina
	Treubaria setigera
	Treubaria triappendiculata
CHRYSOPHYTA	Chromulina sp.
	Chrysococcus sp.?
	Chrysophycean cyst
	Codonosiga botrytis
	Codonosigopsis sp.
	Dinobryon - cyst
	Dinobryon bavaricum
	Dinobryon divergens
	Dinobryon sociale
	Dinobryon sociale v. americanum
	Dinobryon utriculus v. tabellariae
	Haptophyte sp.
	Kephyrion sp.
	Kephyrion sp. #1 -PseudoKephyrion entzii
	Kephyrion sp. #2
	Mallomonas majorensis
	Mallomonas sp.
	Ochromonas sp.
	Ochromonas sp. - ovoid
	Ochromonas sp. - sphere
	PseudoKephyrion millerense
	Pseudotetraedron neglectum
	Pseudotetraedron sp.?
	Unidentified coccoid - ovoid
	Unidentified coccoid - sphere
	Unidentified coccoids
	Unidentified loricate - sphere
COLORLESS FLAGELLATES	Bicoeca campanulata
	Bicoeca petiolata
	Bicoeca socialis
	Colorless flagellates
	Salpingoeca amphorae
	Salpingoeca gracilis
CRYPTOPHYTA	Chroomonas acuta
	Chroomonas caudata
	Chroomonas norstedtii
	Cryptomonas - cyst
	Cryptomonas brevis
	Cryptomonas caudata
	Cryptomonas erosa

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CRYPTOPHYTA	Cryptomonas erosa v. reflexa
	Cryptomonas erosa?
	Cryptomonas lobata
	Cryptomonas lobata?
	Cryptomonas lucens
	Cryptomonas marssonii
	Cryptomonas marssonii v.?
	Cryptomonas obovata
	Cryptomonas ovata
	Cryptomonas ovata?
	Cryptomonas phaseolus
	Cryptomonas phaseolus?
	Cryptomonas platyuris
	Cryptomonas pyrenoidifera
	Cryptomonas reflexa
	Cryptomonas rostratiformis
	Cryptomonas sp.
	Cryptomonas tenuis
	Cryptomonas tetrapyreniodiosa
	Rhodomonas lacustris
	Rhodomonas lens
	Rhodomonas minuta v. nannoplanKtica
CYANOPHYTA	Agmenellum quadruplicatum
	Anabaena flos-aquae
	Anabaena sp.
	Anabaena spiroides
	Anabaena spiroides?
	Anacystis cyanea
	Anacystis incerta
	Anacystis marina
	Anacystis montana
	Anacystis montana v. major
	Anacystis montana v. minor
	Anacystis thermalis
	Aphanizomenon flos-aquae
	Aphanizomenon flos-aquae?
	Coccochloris peniocystis
	Coelosphaerium dubium
	Coelosphaerium naegelianum
	Cyanophycean filament
	Gloeothece ruprestris
	Gloeothece ruprestris?
	Gomphosphaeria lacustris
	Merismopedia glauca
	Merismopedia tenuissima
	Oscillatoria limnetica
	Oscillatoria sp.
	Oscillatoria subbrevis
	Oscillatoria tenuis

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
OSWEGO RIVER AND HARBOR STATIONS - 1981

DIVISION	TAXON
CYANOPHYTA	Oscillatoria tenuis v. tergistina
	Rhaphidiopsis mediterranea
EUGLENOPHYTA	Euglena sp.
	Phacus sp.
	Trachelomonas sp.
	Trachelomonas sp. -ovoid
	Trachelomonas sp.-sphere
PYRROPHYTA	Amphidinium sp.
	Ceratium hirundinella
	Gymnodinium ordinatum?
	Gymnodinium sp.
	Gymnodinium sp. #1
	Gymnodinium sp. #3
	Gymnodinium sp. #5
	Peridinium - cyst
	Peridinium aciculiferum
	Peridinium cinctum
	Peridinium inconspicuum
	Peridinium polonicum
	Peridinium sp.
	Peridinium viguieri
UNIDENTIFIED FLAGELLATES	Unidentified flagellate #01
	Unidentified flagellate - ovoid
	Unidentified flagellate - spherical
XANTHOPHYTA	Chlorobotrys regularis

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
NIAGARA RIVER STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Achnanthes clevei
	Achnanthes minutissima
	Actinocyclus normanii f. subsalsa
	Amphora perpusilla
	Asterionella formosa
	Cocconeis pediculus
	Cocconeis placentula v. lineata
	Cyclotella antiqua?
	Cyclotella atomus
	Cyclotella comensis
	Cyclotella comta
	Cyclotella meneghiniana
	Cyclotella michiganiana
	Cyclotella pseudostelligera
	Cyclotella sp.
	Cyclotella stelligera
	Cymbella affinis
	Cymbella minuta
	Cymbella sp.
	Diatoma tenue
	Diatoma tenue v. elongatum
	Fragilaria capucina
	Fragilaria capucina v. mesolepta
	Fragilaria construens v. pumila
	Fragilaria crotonensis
	Fragilaria pinnata
	Fragilaria sp.
	Fragilaria vaucheriae
	Gomphonema dichotomum
	Gomphonema olivaceoides
	Gomphonema olivaceum
	Gomphonema parvulum
	Gomphonema sp.
	Gomphonema tenellum
	Gyrosigma sciotense
	Melosira distans
	Melosira granulata
	Melosira islandica
	Melosira italica subsp. subarctica
	Navicula atomus
	Navicula capitata v. hungarica
	Navicula cryptocephala v. veneta
	Navicula decussis
	Navicula gregaria
	Navicula lanceolata
	Navicula latens?
	Navicula menisculus v. upsaliensis
	Navicula pupula
	Navicula radiosa v. tenella
	Navicula seminulum

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
NIAGARA RIVER STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Navicula sp.
	Navicula splendicula
	Navicula viridula v. avenacea
	Navicula vulpina
	Nitzschia acicularioides
	Nitzschia acicularis
	Nitzschia acicularis?
	Nitzschia angustata
	Nitzschia angustata v. acuta
	Nitzschia capitellata
	Nitzschia dissipata
	Nitzschia graciliformis
	Nitzschia gracilis
	Nitzschia gracilis?
	Nitzschia hungarica
	Nitzschia impressa
	Nitzschia intermedia
	Nitzschia lauenburgiana
	Nitzschia palea
	Nitzschia palea v. debilis
	Nitzschia pumila?
	Nitzschia recta
	Nitzschia romana
	Nitzschia sociabilis
	Nitzschia sp.
	Nitzschia spiculoides
	Nitzschia spiculum
	Nitzschia tryblionella v. debilis
	Nitzschia valdestrita
	Pinnularia brebissonii v. diminuta
	Rhoiocosphenia curvata
	Skeletonema sp.
	Stephanodiscus alpinus
	Stephanodiscus binderanus
	Stephanodiscus hantzschii
	Stephanodiscus minutus
	Stephanodiscus niagarae
	Stephanodiscus sp.
	Stephanodiscus sp. #03
	Stephanodiscus sp. #04
	Stephanodiscus sp. -auxospore
	Stephanodiscus subtilis
	Stephanodiscus tenuis
	Surirella angusta
	Surirella birostrata
	Surirella ovalis
	Surirella ovata
	Surirella ovata v. salina
	Synedra delicatissima v. angustissima
	Synedra filiformis

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
NIAGARA RIVER STATIONS - 1981

DIVISION	TAXON
BACILLARIOPHYTA	Synedra filiformis v. exilis
	Synedra ostenfeldii
	Synedra parasitica v. subconstricta
	Synedra ulna v. chaseana
	Synedra ulna v. danica
	Synedra ulna v. subaequalis
	Tabellaria fenestrata
	Tabellaria fenestrata v. geniculata
	Tabellaria flocculosa
CHLOROPHYTA	Ankistrodesmus falcatus
	Ankistrodesmus falcatus?
	Ankistrodesmus gelifactum
	Ankistrodesmus sp. #02
	Ankistrodesmus sp.?
	Chlamydocapsa sp.
	Chlamydomonas globosa
	Chlamydomonas globosa?
	Chlamydomonas sp.
	Chlamydomonas sp. - ovoid
	Chlamydomonas sp. - sphere
	Coelastrum microporum
	Cosmarium sp.
	Crucigenia quadrata
	Dictyosphaerium pulchellum
	Elakatothrix gelatinosa
	Green coccoid #04
	Green coccoid - bacilliform
	Green coccoid - bicells
	Green coccoid - fusiform
	Green coccoid - oval
	Green coccoid - ovoid
	Green coccoid - sphere
	Green coccoid - sphere (large)
	Green flagellate - ovoid
	Micractinium sp. #1
	Monoraphidium contortum
	Mougeotia sp.
	Oedogonium sp. #01
	Oocystis borgei
	Oocystis pusilla
	Pediastrum boryanum
	Scenedesmus denticulatus
	Scenedesmus ecornis
	Scenedesmus intermedius
	Scenedesmus intermedius v. balatonicus
	Scenedesmus opoliensis
	Scenedesmus quadricauda
	Scenedesmus sp
	Scenedesmus spinosus

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
NIAGARA RIVER STATIONS - 1981

DIVISION	TAXON
CHLOROPHYTA	Selenastrum minutum
	Tetraedron minimum
	Tetrastrum heteracanthum
	Tetrastrum lacustris
	Tetrastrum staurogeniaeforme
	Treubaria setigera
CHRYSOPHYTA	Bitrichia ollula
	Chrysolykos skujae
	Dinobryon cylindricum
	Dinobryon divergens
	Dinobryon sertularia
	Dinobryon sociale
	Dinobryon sociale v. americanum
	Haptophyte sp.
	Kephyrion spirale
	Mallomonas sp.
	Ochromonas pinguis
	Ochromonas sp.
	Ochromonas sp. - ovoid
	Pseudokephyrion latum
	Pseudotetraedron neglectum
	Synura sp.
COLORLESS FLAGELLATES	Bicoeca sp.
	Bicoeca sp. #01
	Bicoeca sp. #02
	Bicoeca sp. #03
	Colorless flagellates
	Salpingoeca amphorae
	Sphaeroeca sp.
	Stylotheca aurea
CRYPTOPHYTA	Chilomonas sp.
	Chroomonas acuta
	Chroomonas norstedtii
	Cryptomonas - cyst
	Cryptomonas caudata
	Cryptomonas curvata
	Cryptomonas erosa
	Cryptomonas erosa v. reflexa
	Cryptomonas marssonii
	Cryptomonas marssonii v.?
	Cryptomonas ovata
	Cryptomonas parapyrenoidifera
	Cryptomonas phaseolus
	Cryptomonas pusilla
	Cryptomonas pyrenoidifera
	Cryptomonas reflexa
	Cryptomonas rostratiformis

SPECIES LIST
LAKE ONTARIO PHYTOPLANKTON STUDY
NIAGARA RIVER STATIONS - 1981

DIVISION	TAXON
CRYPTOPHYTA	Cryptomonas sp.
	Cryptomonas sp. #3
	Cryptomonas tetrapyreniodiosa
	Rhodomonas lacustris
	Rhodomonas lens
	Rhodomonas minuta
	Rhodomonas minuta v. nannoplanktica
	Sennia parvula
CYANOPHYTA	Anacystis incerta
	Anacystis marina
	Coccochloris peniocystis
	Oscillatoria limnetica
	Oscillatoria limnetica?
	Oscillatoria tenuis
EUGLENOPHYTA	Colacium sp.?
	Euglena sp.
PYRROPHYTA	Amphidinium sp.
	Gymnodinium helveticum
	Gymnodinium sp. #1
	Gymnodinium sp. #2
	Peridinium - cyst
	Peridinium aciculiferum
	Peridinium sp.
UNIDENTIFIED FLAGELLATES	Unidentified flagellate #01
	Unidentified flagellate - ovoid
	Unidentified flagellate - spherical

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 1 (APRIL 27 - 28)
SUMMARY (TOTAL) OF PHYTOPLANKTON BIOVOLUME [(CUBIC UM/ML) X 1000] BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
NI 03	INTEG	594.91	51.82	9.90	24.37	1.46	124.94	1.85	912.82	26.72	-0.00	-0.00	1,748.79
NI 04	INTEG	961.30	38.66	10.15	15.06	1.65	50.85	-0.00	643.51	21.63	-0.00	-0.00	1,742.81
NI 06	SURFACE	669.31	25.97	10.83	10.05	0.33	103.25	-0.00	247.68	15.33	-0.00	-0.00	1,082.75
NI 07	SURFACE	327.76	9.36	3.71	0.27	-0.00	33.03	0.46	40.77	9.35	-0.00	-0.00	424.73
NI 08	INTEG	384.85	10.37	1.09	0.22	0.10	52.58	0.60	84.93	9.06	-0.00	-0.00	543.81
NI 09	SURFACE	307.11	21.05	2.52	0.34	0.08	48.15	-0.00	88.08	8.67	-0.00	-0.00	476.00
NI 10	1	618.61	38.38	25.33	18.53	2.00	97.44	0.64	427.99	23.96	-0.00	-0.00	1,252.88
NI 13	INTEG	545.56	17.28	22.28	60.88	5.33	159.66	-0.00	540.21	22.68	-0.00	-0.00	1,373.88
NI 14	INTEG	929.34	27.84	20.06	21.62	3.73	130.58	-0.00	383.08	24.16	-0.00	-0.00	1,540.42
NI 15	INTEG	668.14	17.97	1.91	1.15	0.14	63.69	1.46	44.78	14.20	-0.00	-0.00	813.45
NI 16	1	373.62	12.85	1.52	0.13	0.01	35.18	-0.00	90.39	11.29	-0.00	-0.00	524.98
NI 17	1	333.11	19.60	6.62	15.48	6.44	67.49	-0.00	367.90	18.08	-0.00	-0.00	834.73
NI 18	INTEG	1,153.95	60.89	30.69	29.80	2.00	63.41	-0.00	567.55	36.39	-0.00	-0.00	1,944.70
NI 19	INTEG	827.85	49.54	18.20	5.35	1.00	131.68	-0.00	223.51	48.55	-0.00	-0.00	1,305.68
NI 20	INTEG	851.28	31.19	53.25	18.56	4.78	33.96	-0.00	104.22	21.36	-0.00	-0.00	1,118.60
NI 21	INTEG	578.91	35.50	31.34	16.37	3.56	107.40	23.51	469.04	26.54	-0.00	-0.00	1,292.18
NI 22	INTEG	1,113.27	108.14	22.62	26.96	4.29	76.77	-0.00	170.84	23.88	-0.00	-0.00	1,546.78
NI 01	INTEG	860.30	96.09	27.44	14.46	4.13	199.20	-0.00	525.51	60.42	-0.00	-0.00	1,787.55
NI 02	INTEG	833.55	103.13	24.34	17.21	62.15	179.20	-0.00	1,045.66	39.07	-0.00	-0.00	2,304.31
NI 05	INTEG	598.98	30.28	20.56	4.60	9.87	91.00	-0.00	193.50	52.26	-0.00	-0.00	1,001.05

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 2 (JULY 30 - AUGUST 1)
SUMMARY (TOTAL) OF PHYTOPLANKTON BIOVOLUME [(CUBIC UM/ML) X 1000] BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	991.35	1,072.96	67.02	5.93	1.05	560.45	111.40	1.23	19.14	4.39	-0.00	2,834.92
OS 04	INTEG	547.91	624.76	58.10	2.22	0.82	340.61	-0.00	21.93	22.42	-0.00	-0.00	1,618.78
OS 05	INTEG	747.14	1,734.06	65.39	10.35	1.00	1,360.13	244.29	102.23	33.67	-0.00	-0.00	4,298.25
OS 07	INTEG	450.76	894.91	40.41	4.04	2.13	477.09	-0.00	83.06	7.66	-0.00	-0.00	1,960.08
OS 09	INTEG	134.81	218.63	23.37	4.80	0.27	1,085.32	-0.00	17.54	19.32	-0.00	-0.00	1,504.06
OS 11	INTEG	69.99	117.43	71.93	5.07	1.10	1,448.74	-0.00	-0.00	13.29	-0.00	-0.00	1,727.55
OS 12	INTEG	32.87	276.58	30.33	11.45	-0.00	1,248.41	-0.00	80.49	14.38	-0.00	-0.00	1,694.51
OS 13	INTEG	73.20	170.56	45.70	14.14	-0.00	1,482.96	-0.00	50.54	11.40	-0.00	-0.00	1,848.50

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 3 (AUGUST 30 - SEPTEMBER 2)
SUMMARY (TOTAL) OF PHYTOPLANKTON BIOVOLUME [(CUBIC UM/ML) X 1000] BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	2,583.56	649.49	355.67	1.42	0.90	78.30	10.41	1,393.59	161.50	-0.00	-0.00	5,234.84
OS 04	INTEG	2,285.57	684.30	197.78	44.14	6.16	158.69	2.19	1,523.74	44.94	-0.00	-0.00	4,947.51
OS 05	INTEG	1,909.63	768.59	300.32	5.54	-0.00	145.81	-0.00	561.19	59.83	-0.00	-0.00	3,750.92
OS 07	INTEG	2,282.33	1,237.31	558.12	63.47	2.90	86.93	-0.00	1,106.93	75.52	-0.00	-0.00	5,413.49
OS 09	INTEG	678.02	745.29	31.31	13.27	0.69	118.92	-0.00	410.65	38.98	-0.00	-0.00	2,037.13
OS 11	INTEG	-0.00	972.60	112.19	15.47	0.35	168.92	-0.00	232.24	42.49	-0.00	-0.00	1,544.25
OS 12A	INTEG	546.55	269.44	15.55	5.10	0.23	174.31	-0.00	91.21	28.72	-0.00	-0.00	1,131.11
OS 13	INTEG	403.18	423.96	61.82	15.15	-0.00	292.41	-0.00	2,184.42	31.27	-0.00	-0.00	3,412.20
OS 17	INTEG	651.90	316.20	119.90	10.41	0.55	255.41	-0.00	1,158.29	42.01	-0.00	-0.00	2,554.67
OS 17	INTEG	497.95	1,977.60	97.54	5.43	0.23	146.56	-0.00	709.87	33.77	-0.00	-0.00	3,468.95
OS 17	INTEG	413.74	428.72	45.98	11.36	1.30	206.25	-0.00	59.94	58.46	-0.00	-0.00	1,225.76
OS 17B	BOTTOM	348.92	342.25	39.38	0.71	0.46	108.72	-0.00	11.75	13.89	-0.00	-0.00	866.09
OS 19	SURFACE	417.58	757.05	48.15	14.82	0.19	165.39	-0.00	270.85	31.11	-0.00	-0.00	1,705.14
OS 19	INTEG	228.53	291.21	135.64	7.32	0.23	119.58	-0.00	348.07	19.69	-0.00	-0.00	1,150.27
OS 19	INTEG	553.56	422.21	18.75	14.34	-0.00	173.99	-0.00	8.63	22.22	-0.00	-0.00	1,213.70
OS 19B	BOTTOM	160.01	196.47	3.76	12.16	0.23	42.03	-0.00	244.24	16.20	-0.00	4.28	679.40
OS 22	INTEG	1,697.49	1,399.04	2,324.55	29.00	0.93	110.44	-0.00	361.12	93.08	-0.00	-0.00	6,015.65
OS 28	INTEG	1,060.11	463.27	60.45	9.77	1.44	75.76	-0.00	1,299.11	44.31	-0.00	-0.00	3,014.23
OS 29	INTEG	900.37	419.01	37.68	10.13	2.04	187.58	-0.00	909.24	26.78	-0.00	-0.00	2,492.84
OS 37	INTEG	580.89	514.29	42.79	21.51	0.76	100.42	-0.00	895.54	16.74	-0.00	-0.00	2,172.93

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 4 (OCTOBER 8 - 10)
SUMMARY (TOTAL) OF PHYTOPLANKTON BIOVOLUME [(CUBIC UM/ML) X 1000] BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	1,823.89	291.72	22.55	3.31	1.10	91.35	-0.00	-0.00	23.63	-0.00	-0.00	2,257.54
OS 04	INTEG	9,869.59	344.04	134.08	8.51	2.00	303.55	-0.00	-0.00	27.38	-0.00	-0.00	10,689.16
OS 05	SURFACE	6,383.55	418.48	138.01	17.29	2.13	288.59	-0.00	-0.00	40.24	-0.00	-0.00	7,288.28
OS 07	INTEG	2,161.38	332.59	59.48	13.29	0.93	263.39	-0.00	222.03	18.79	-0.00	-0.00	3,071.88
OS 11	INTEG	1,222.29	515.97	106.76	4.18	0.99	272.87	-0.00	6.03	26.04	-0.00	-0.00	2,155.13
OS 17	INTEG	906.71	106.93	16.98	4.42	0.55	377.58	-0.00	725.18	10.31	-0.00	-0.00	2,148.67
OS 19	INTEG	1,619.24	204.61	62.07	7.13	0.34	232.23	-0.00	2.19	6.13	-0.00	-0.00	2,133.95
OS 22A	INTEG	6,174.05	181.20	12.60	3.38	0.12	479.43	-0.00	768.51	10.15	-0.00	-0.00	7,629.44
OS 23	INTEG	3,065.40	645.31	175.97	8.95	1.21	548.72	-0.00	147.23	12.56	-0.00	-0.00	4,605.35
OS 28	INTEG	12096.66	525.55	89.90	16.47	4.41	425.20	5.55	4.51	26.25	-0.00	-0.00	13,194.51
OS 29	INTEG	1,599.85	1,916.65	27.68	6.34	0.82	541.46	-0.00	439.38	17.07	-0.00	-0.00	4,549.25
OS 37	INTEG	1,947.29	199.61	14.99	1.94	1.32	111.65	-0.00	46.91	14.94	-0.00	-0.00	2,338.64

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 1 (APRIL 27 - 28)
SUMMARY (TOTAL) OF PHYTOPLANKTON CELLS PER ML BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
NI 03	INTEG	380.52	1,178.11	34,115.81	134.99	67.49	331.34	12.27	79.77	509.29	-0.00	-0.00	36,809.59
NI 04	INTEG	982.09	844.31	35,520.94	141.14	49.09	208.62	-0.00	55.22	447.93	-0.00	-0.00	38,249.34
NI 06	SURFACE	687.30	431.98	32,113.04	108.01	9.82	358.35	-0.00	39.28	358.34	-0.00	-0.00	34,106.12
NI 07	SURFACE	312.50	230.70	4,032.54	15.54	-0.00	91.63	0.82	9.82	209.44	-0.00	-0.00	4,902.99
NI 08	INTEG	356.68	222.54	4,058.72	13.09	2.45	136.63	0.82	9.01	177.53	-0.00	-0.00	4,977.47
NI 09	SURFACE	314.14	364.90	4,555.32	14.73	1.64	119.44	-0.00	15.55	263.44	-0.00	-0.00	5,649.16
NI 10	1	944.96	840.61	91,934.76	165.67	73.64	337.51	6.14	36.82	589.05	-0.00	-0.00	94,929.16
NI 13	INTEG	564.62	679.06	79,358.12	458.14	98.17	359.97	-0.00	57.27	597.23	-0.00	-0.00	82,172.58
NI 14	INTEG	793.40	924.48	73,353.09	139.08	40.90	343.60	-0.00	32.72	654.50	-0.00	-0.00	76,281.77
NI 15	INTEG	458.12	334.63	4,700.13	68.72	4.09	157.88	0.82	12.27	259.35	-0.00	-0.00	5,996.01
NI 16	1	354.30	197.17	4,360.60	7.36	0.82	109.64	-0.00	11.46	209.44	-0.00	-0.00	5,250.79
NI 17	1	484.36	549.80	22,842.05	119.45	83.46	243.81	-0.00	31.09	359.97	-0.00	-0.00	24,713.99
NI 18	INTEG	850.99	843.68	110,569.60	139.09	65.45	278.16	-0.00	57.27	752.68	-0.00	-0.00	113,556.92
NI 19	INTEG	1,016.10	602.16	28,081.33	153.81	21.28	302.72	-0.00	26.18	726.50	-0.00	-0.00	30,930.08
NI 20	INTEG	1,358.06	687.23	177,402.23	106.34	81.81	98.17	-0.00	16.36	539.96	-0.00	-0.00	180,290.16
NI 21	INTEG	875.61	621.78	114,864.75	139.09	24.54	139.07	8.18	49.09	441.78	-0.00	-0.00	117,163.89
NI 22	INTEG	1,194.61	957.21	83,555.11	196.35	57.27	147.26	-0.00	24.54	621.77	-0.00	-0.00	86,754.12
NI 01	INTEG	1,080.09	1,014.49	73,475.80	98.16	57.27	417.24	-0.00	40.91	1,120.83	-0.00	-0.00	77,304.79
NI 02	INTEG	883.72	1,063.56	89,396.52	122.72	441.79	343.61	-0.00	81.81	801.76	-0.00	-0.00	93,135.49
NI 05	INTEG	728.07	711.77	75,717.47	89.99	24.54	188.17	-0.00	24.54	1,096.29	-0.00	-0.00	78,580.84

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 2 (JULY 30 - AUGUST)
SUMMARY (TOTAL) OF PHYTOPLANKTON CELLS PER ML BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	5,659.17	8,501.36	70,096.95	57.27	24.54	539.96	16.36	8.18	368.16	16.36	-0.00	85,288.31
OS 04	INTEG	3,313.36	7,537.55	63,519.21	130.89	49.09	458.15	-0.00	16.36	548.14	-0.00	-0.00	75,572.75
OS 05	INTEG	4,798.74	9,350.25	78,552.27	85.89	49.09	1,313.09	110.44	61.35	429.52	-0.00	-0.00	94,750.64
OS 07	INTEG	2,724.32	5,957.85	58,054.14	278.16	57.27	638.12	-0.00	24.54	351.79	-0.00	-0.00	68,086.19
OS 09	INTEG	670.89	1,457.27	46,551.31	98.17	8.18	646.32	-0.00	8.18	384.52	-0.00	-0.00	49,824.84
OS 11	INTEG	380.44	2,147.57	67,409.39	208.62	49.09	773.13	-0.00	-0.00	454.06	-0.00	-0.00	71,422.30
OS 12	INTEG	253.60	1,522.72	82,736.98	409.06	-0.00	417.25	-0.00	24.54	335.43	-0.00	-0.00	85,699.58
OS 13	INTEG	442.27	1,565.60	57,669.64	335.43	-0.00	662.69	-0.00	24.54	196.35	-0.00	-0.00	60,896.52

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 3 (AUGUST 30 - SEPTEMBER)
SUMMARY (TOTAL) OF PHYTOPLANKTON CELLS PER ML BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	6,348.68	8,181.46	114,782.95	65.45	40.90	703.58	-0.00	73.63	1,578.98	-0.00	-0.00	131,775.63
OS 04	INTEG	5,760.82	5,974.36	60,353.09	515.42	212.71	801.77	8.18	163.62	1,161.74	-0.00	-0.00	74,951.71
OS 05	INTEG	4,729.19	5,539.73	71,929.55	188.16	-0.00	899.93	-0.00	130.90	1,325.37	-0.00	-0.00	84,742.83
OS 07	INTEG	6,061.14	6,973.28	84,225.97	319.06	81.81	1,047.20	-0.00	106.36	1,513.53	-0.00	-0.00	100,328.35
OS 09	INTEG	1,693.71	2,339.86	27,734.45	351.79	32.72	859.02	-0.00	32.72	1,497.17	-0.00	-0.00	34,541.44
OS 11	INTEG	-0.00	3,315.42	82,262.48	638.13	16.36	1,104.46	-0.00	32.72	1,906.23	-0.00	-0.00	89,275.80
OS 12A	INTEG	989.26	2,006.96	21,958.48	343.62	16.36	924.48	-0.00	16.36	752.68	-0.00	-0.00	27,008.20
OS 13	INTEG	820.19	3,070.00	27,186.30	769.03	-0.00	1,055.37	-0.00	65.46	973.57	-0.00	-0.00	33,939.92
OS 17	INTEG	1,227.25	2,080.88	32,356.83	368.15	16.36	1,489.00	-0.00	73.63	1,194.46	-0.00	-0.00	38,806.56
OS 17	INTEG	940.27	2,627.22	17,425.55	392.70	16.36	1,276.28	-0.00	40.90	981.76	-0.00	-0.00	23,701.04
OS 17	INTEG	957.24	1,795.54	18,096.92	310.89	65.45	924.47	-0.00	24.54	859.03	-0.00	-0.00	23,034.08
OS 17B	BOTTOM	400.85	952.85	16,501.59	65.45	32.73	351.79	-0.00	8.18	449.97	-0.00	-0.00	18,763.41
OS 19	SURFACE	417.02	1,589.17	19,258.68	589.05	8.18	1,341.71	-0.00	16.36	998.12	-0.00	-0.00	24,218.29
OS 19	INTEG	286.34	1,393.65	18,555.08	621.77	16.36	1,006.31	-0.00	16.36	908.12	-0.00	-0.00	22,803.99
OS 19	INTEG	465.39	1,869.15	25,108.26	613.58	-0.00	736.31	-0.00	8.18	809.95	-0.00	-0.00	29,610.82
OS 19B	BOTTOM	122.73	609.07	10,831.98	286.34	16.36	319.06	-0.00	8.18	425.43	-0.00	8.18	12,627.33
OS 22	INTEG	6,731.95	5,645.09	55,517.97	597.23	57.27	1,259.91	-0.00	24.54	1,750.79	-0.00	-0.00	71,584.75
OS 28	INTEG	2,961.65	2,815.35	50,854.66	376.33	49.09	1,014.48	-0.00	130.90	998.12	-0.00	-0.00	59,200.58
OS 29	INTEG	1,497.56	2,473.76	27,906.25	515.42	130.90	1,456.27	-0.00	40.90	793.58	-0.00	-0.00	34,814.64
OS 37	INTEG	1,742.21	2,164.54	32,119.60	163.62	32.72	719.94	-0.00	40.90	343.61	-0.00	-0.00	37,327.14

LAKE ONTARIO INTENSIVE STUDY - 1981: CRUISE 4 (OCTOBER 8 - 10)
SUMMARY (TOTAL) OF PHYTOPLANKTON CELLS PER ML BY DIVISION AND BY STATION
BAC=BACILLARIOPHYTA; CAT=CHLOROMONADOPHYTA; COL=COLORLESS FLAGELLATES; CYA=CYANOPHYTA
UNI=UNIDENDTIFIED FLAGELLATES; EUG=EUGLENOPHYTA; CHL=CHLOROPHYTA; PYR=PYRRHOPHYTA
CRY=CRYPTOPHYTA; XAN=XANOPHYTA; CHR=CHRYSOPHYTA

STATION	DEPTH (M)	BAC	CHL	CYA	CHR	COL	CRY	EUG	PYR	UNI	XAN	CAT	TOTAL
OS 03	INTEG	3,280.43	2,586.26	52,319.09	81.81	32.73	409.06	-0.00	-0.00	523.60	-0.00	-0.00	59,232.98
OS 04	INTEG	3,493.01	4,164.16	63,461.95	171.81	106.36	572.67	-0.00	-0.00	744.49	-0.00	-0.00	72,714.45
OS 05	SURFACE	3,983.45	4,729.78	61,629.36	196.35	57.27	409.05	16.36	-0.00	458.15	-0.00	-0.00	71,479.77
OS 07	INTEG	2,356.14	2,741.66	51,754.59	908.11	57.27	711.74	-0.00	8.18	556.32	-0.00	-0.00	59,094.01
OS 11	INTEG	2,257.89	2,061.69	43,229.73	57.26	24.54	899.93	-0.00	16.36	580.87	-0.00	-0.00	49,128.27
OS 17	INTEG	817.96	876.42	21,770.31	98.18	16.36	1,423.54	-0.00	16.36	359.97	-0.00	-0.00	25,379.10
OS 19	INTEG	752.64	1,636.25	32,152.32	212.71	8.18	932.67	-0.00	8.18	179.99	-0.00	-0.00	35,882.94
OS 22A	INTEG	2,012.71	1,350.93	24,061.05	73.63	8.18	1,513.54	-0.00	16.36	253.62	-0.00	-0.00	29,290.02
OS 23	INTEG	1,487.88	3,972.14	36,619.27	736.31	57.27	1,358.08	-0.00	16.36	523.60	-0.00	-0.00	44,770.91
OS 28	INTEG	5,390.76	5,352.44	102,797.42	1,799.87	237.25	646.31	8.18	8.18	670.86	-0.00	-0.00	116,911.27
OS 29	INTEG	1,177.94	2,872.64	33,084.99	204.53	24.54	2,069.86	-0.00	32.72	490.87	-0.00	-0.00	39,958.09
OS 37	INTEG	2,536.49	1,826.43	39,981.77	57.27	65.45	335.43	-0.00	16.36	343.62	-0.00	-0.00	45,162.82

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15. SUPPLEMENTARY NOTES
Paul E. Bertram
Editor

16. ABSTRACT

During 1981, the U.S. EPA undertook 4 limnological surveys of nearshore waters of Lake Ontario, including the Niagara River Plume, the Rochester Embayment and Oswego Harbor. Water samples from 81 locations were analyzed for 22 physical and chemical parameters. Cluster analyses were used to identify station groupings as Lake, mixing or nearshore, and river source areas. Spatial and temporal differences in the data are discussed.

Phytoplankton samples were collected during 3 surveys of the Oswego Harbor and 1 survey of the Niagara River plume area. Species identifications, enumerations and biovolumes are reported. The spatial and temporal differences in phytoplankton community structure in the Oswego Harbor are discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Limnology	Phytoplankton		
Lake Ontario	Oswego Harbor		
Nutrients	Niagara River		
Phosphorus	Rochester Embayment		
Nitrogen	Water Quality		
Silica			

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